CANADA

DEPARTMENT OF MINES

GEOLOGICAL SURVEY BRANCH

HON. W. B. NANTEL, MINISTER; A. P. LOW, DEPUTY MINISTER;
R. W. BROCK, DIRECTOR.

MEMOIR No. 27

REPORT OF THE COMMISSION

APPOINTED TO INVESTIGATE

TURTLE MOUNTAIN, FRANK, ALBERTA

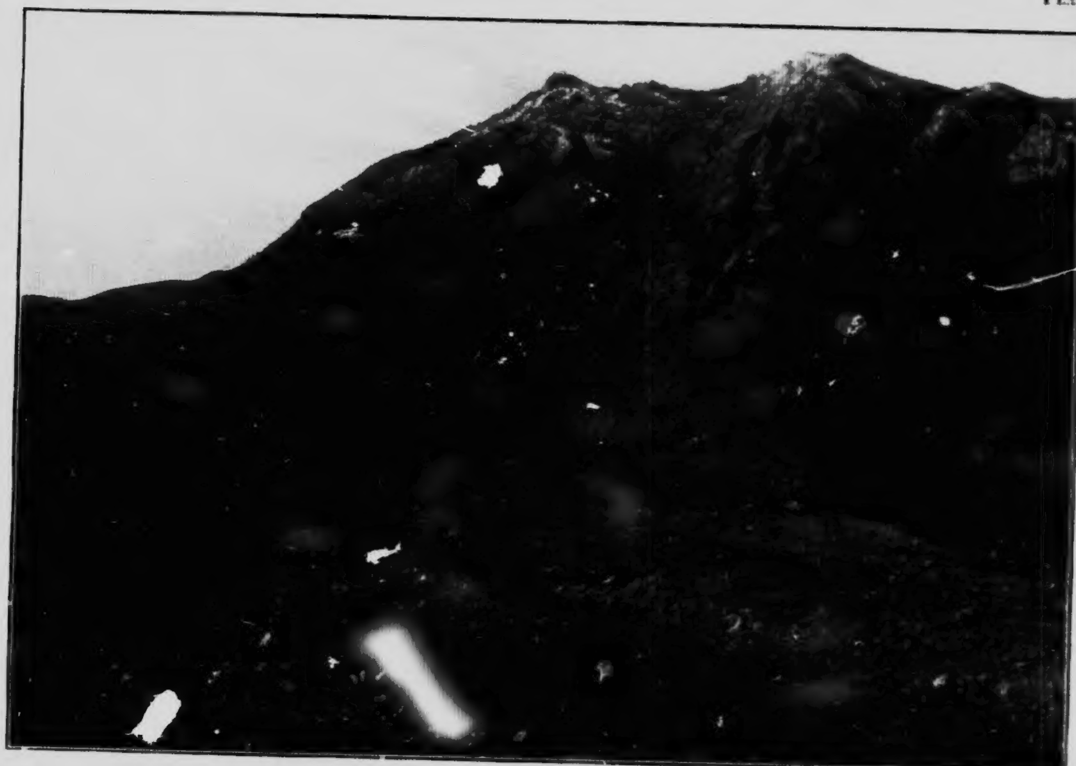
1911

OTTAWA
GOVERNMENT PRINTING BUREAU
1912

No. 1211

Frontispiece.

PLATE I.



Turtle mountain, near Frank, Alberta

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LETTER OF TRANSMITTAL.

December 2, 1911.

The Honourable W. B. Nantel,
Minister of Mines,
Ottawa.

Sir,—In pursuance of the instructions of the Honourable the Minister of Mines, transmitted through the Director of the Geological Survey, we have examined Turtle mountain at Frank, Alberta, and workings of the mines of the Canadian Coal Consolidated, Limited, with the view of determining whether or not mining operations are likely to bring about a landslide from the mountain and thus endanger lives and property in the town. Furthermore, we have considered the possibility of a slide or slides from natural causes independent of mining. The labour involved in the preparation of the detailed map of Turtle mountain and vicinity has been so great that it has prevented the completion of the report at an earlier date.

We beg leave to submit the following report.

We have the honour to be, sir,

Your obedient servants,

(Signed) **Reginald A. Daly,**
W. G. Miller,
George S Rice,

Commissioners appointed to investigate the condition of Turtle mountain.

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ILLUSTRATIONS

Photographs.

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Maps.

NOTE.—The above maps are only preliminary; the regular topographical map—now in preparation—will be issued later on.

TURTLE MOUNTAIN, FRANK, ALBERTA.

HISTORICAL SUMMARY.

Report of Landslide of 1903.

Under date June 12, 1903, Messrs. R. G. McConnell and R. W. Brock of the Geological Survey of Canada, acting as a commission appointed by the Honourable the Minister of the Interior, submitted a report on their examination of the Frank landslide which took place on April 29, of that year. The slide entailed the loss of about seventy lives of people in the town of Frank, together with the destruction of much property, including nearly 7,000 feet of the Crows Nest railway.

In their report, Messrs. McConnell and Brock say that the slide was due, not to a single cause, but to a combination of causes, among which the opening up of large chambers in the mine, situated under the base of the mountain, may have been a contributory cause. Speaking of the North peak and shoulder of the mountain overlooking the town, they say "the closing of the chambers in the mine, after the coal has been withdrawn, perhaps long after the inhabitants of the town have lost all dread of another disaster, may precipitate it suddenly in a second destructive slide. Since this possibility must always overhang the town, it certainly seems advisable that it be moved a short distance up the valley beyond the reach of danger."[1]

More Recent Observations.

Since the report was published, officers of the Geological Survey have visited Frank from time to time and have examined the mountain. From several examinations he has made of the mountain, Mr. Brock has decided that cracks have formed in that part of the mountain overlooking the town, and that one or two cracks in the vicinity of the north shoulder have gradually widened

[1] Extract from Part VIII, Annual Report, 1903, Department Interior, page 17

during the last two years. Moreover, he has decided that the extraction of coal within a certain zone, which he has called the "zone of extreme danger," is likely to precipitate a landslide that would destroy the town. In the Summary Report of the Geological Survey for 1909, he calls attention to the danger which, in his opinion, threatens the town.

The following quotations from letters written by Mr. Brock in 1910, show the views he holds concerning the danger that he considers would arise were coal extracted from certa parts of the mine.

'Of the various causes which were responsible for the big slide there can be no question but that the mining of the coal was a prime one.

'In the report on the Frank slide we expressed our conviction regarding the connexion between mining and the catastrophe. It was not considered necessary to emphasize this point at that time, for the Company had had no means of knowing that its operations were a menace to public safety. Now the case is otherwise. If the mountain is further disturbed by mining operations and a slide occurs the Company would certainly be held responsible.[1]

'Turtle mountain is in a more threatening condition now than last year. This opinion is concurred in by Mr. Boyd. The north shoulder is, of course, the dangerous portion of the mountain. After the slide it was carefully examined and it has been closely watched since then, but until last year I saw no signs of movement or, apart from its structure, of weakness on this north shoulder. Last year I detected two cracks as shown on the sketch map which I sent you last spring. They were so slight, however, that it would not have surprised me if their existence had been questioned. This year, however, they were very marked. The cracks between this shoulder and the North peak also show development during the year. These cracks are significant as indicating movement and unstable conditions. It is true that in some cases the block severed by the crack is not large enough in itself to cause much damage if dislodged, but as the joint planes along which the cracks develop dip towards the face of the cliff, giving the block the form of an inverted wedge, only those near the face can open, the weight of a large block tending to keep the break closed. As the top surface is covered with shingle, only a gaping crack makes itself visible on the surface; hence a dangerous break back from the face, the break along which an enormous slide might take place, might not be detectable on the surface, even at the tir the slide was about to occur.

[1] Letter dated May 12, 1910, addressed to the Canadian Coal Consolidated Limited, Frank, Alta.

'The cracks on the north shoulder prove that its solidity is not to be relied on, and the recent movements indicated by these cracks may very well be ascribed to the disturbing effect of mining that has recently been done in the neighbourhood of the foundation of this shoulder.

'In the face of such facts, I cannot evade the conclusion that mining is too dangerous to be continued. It is my firm opinion that no more liberties can safely be taken with this mountain.

'A large slide would cut off all railway communication and close the mines west of Frank. It might permanently close the pass. The town of Frank would be wiped out with a fearful toll of life. These are some of the risks that are being taken by tampering with the foundation of this mountain. It was unsafe to do what has recently been done in the way of mining. This was pointed out before this work was started and the present unfavourable condition of Turtle mountain as compared to that of last year shows that the opinion then expressed was well founded. No further mining of the seams near the base of Turtle mountain can safely be done."[1]

Report of 1910.

In the summary report of the Geological Survey for 1910, Mr. Brock pointed out the danger to be feared from continued mining at the base of the mountain. Articles based on the report, appearing in the press, excited such interest at Frank that a deputation consisting of Mr. A. A. Müller, general manager of the Canadian Coal Consolidated, Limited, Mr. Moore his legal adviser, and Mr. Harvey Murphy, chairman of the council of the village of Frank, proceeded to Ottawa in the last week of July, 1911, and held a conference with the Minister of the Interior, the Minister of Mines, and the Director of the Geological Survey, with regard to the situation at Frank and the advisability of having an examination and report by a Commission. After further correspondence and interviews, and after consultation with the representatives of the government of Alberta, it was decided to appoint a commission consisting of two geologists and a mining engineer. The undersigned had the honour of being appointed the commissioners.

Visit of Commissioners to Frank.

We arrived in Frank on the morning of October 3, and there met Mr. John Stirling, Provincial Inspector of Mines and Mr. Francis Aspinall, District Inspector. In the afternoon we called

[1] Letter dated, Ottawa, Nov. 3, 1910, addressed to John Stocks, Esq., Deputy Minister, Department of Public Works, Edmonton, Alta.

on Mr. A. A. Müller, General Manager of the Canadian Coal Consolidated, Limited, and at the place of business of Mr. Harvey Murphy, chairman of the council of the village of Frank. Mr. Murphy was, however, out of town at the time. Later in the week we arranged for a conference with Mr. Müller and for one with Mr. Murphy and Mr. Tompkins of the council of the village of Frank. Interviews were also held with other citizens of the village, and with men acquainted with the district.

On the day following our arrival we ascended Turtle mountain under the guidance of Mr. W. H. Boyd, chief topographer of the Geological Survey. Mr. Boyd's acquaintance with Turtle mountain and its surroundings dates back to 1903, when he was associated with Messrs. McConnell and Brock in mapping after the slide. Since then he has made other examinations of the mountain. During the past season Mr. Boyd, with a corps of assistants, has been engaged in making a detailed map of the mountain, the manuscript of which was placed at our service. We are deeply indebted to Mr. Boyd for the information which he furnished us concerning the mountain, and also for the interesting and instructive model of the mountain, based on his map, which he prepared for us.

Mr. Müller, and the mine manager of his Company, Mr. Shone, lent their assistance by accompanying us to the mine workings, and in other ways.

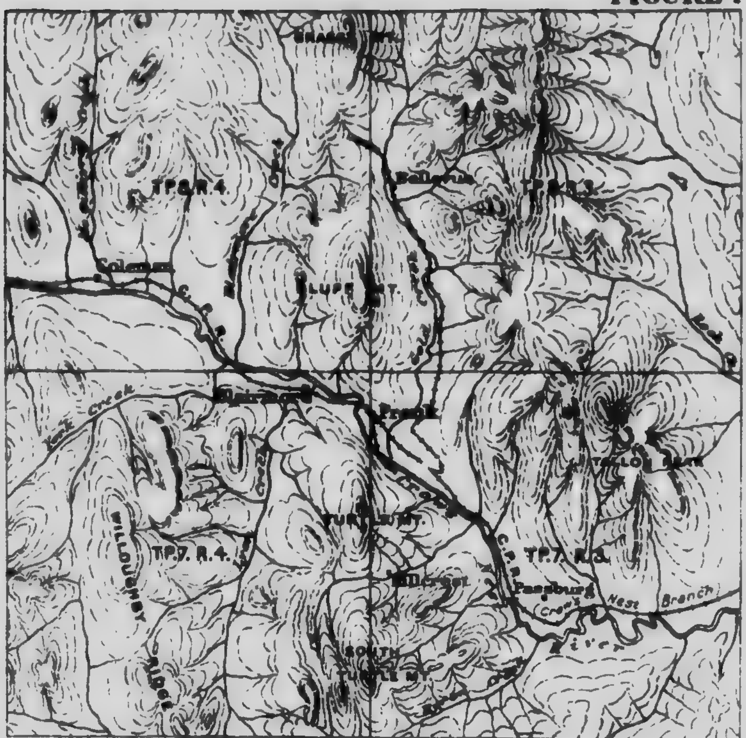
Messrs. Stirling and Aspinall were constantly at hand to give us any assistance in their power.

For valuable aid and courtesies extended while at Frank, the best thanks of the Commissioners are due to all of the gentlemen above mentioned, as well as to others whose names do not appear.

The work at Frank was completed on October 12, and we took train for the east on the evening of that day.

In the following pages is given, as briefly as is consistent with a clear understanding, an account of observations made and information acquired, together with the conclusions at which we have arrived. The report is illustrated with maps, sections, and photographs of a character such as to make a more voluminous text unnecessary.

FIGURE I



West of 5th Meridian

INDEX MAP

Scale, 3 Miles to 1 Inch

INTRODUCTION.

The question whether there is danger of one or more destructive slides in the future involves two sets of considerations. Its investigation obviously implies an inquiry into the existing natural conditions. Are these conditions such as to warrant belief in practical danger to the town of Frank? Secondly, is the stability of Turtle mountain of such a low order that continued mining at its base would essentially add to the danger? As to the advisability of keeping the town in its present situation, these two problems are not of equal importance. If it can be shown that reasonable prudence should counsel the evacuation of the town-site because of the present natural condition of Turtle mountain, the question as to the influence of continued mining on the Frank coal seam becomes distinctly subordinate. Since your Commission believes that nearly all of the town-site is in danger of being overrun by one or more great slides, quite irrespective of the mining operations, the evidence bearing on this essential problem will first be stated.

A. Probability of a Great Slide due to Existing Natural Conditions.

The grounds for your Commission's affirmative answer to the question regarding danger of catastrophe because of the present state of the mountain, may be reviewed under five heads. These are: (1) The special, local conditions favouring such a slide. (2) The general conditions favouring a slide. (3) The similarity of conditions to those preceding the great slide of April, 1903. (4) The weakening of the North peak through the fall of rock in 1903. (5) The existence of new cracks showing incipient movement of the large block culminating in the North peak.

(1) Special Conditions Favouring a Landslide of the First Order.

After a careful study on the ground, your Commission has been forced to conclude that Turtle mountain presents a number of peculiarities which together form a highly special combination leading to continued destructive falls of rock from the North peak and its vicinity. Perhaps nowhere else in the entire Rocky Mountain system is a similar combination of features to be found. It is certain, even without further detailed examination by geologists, that this combination of features is not likely to be exactly paralleled in any other mountain mass of Alberta or of British Columbia. In the present case the form or topography of the mountain, its some-

what complicated structure, the nature of its constituent rocks, and the internal stresses developed within the mountain mass at the time of its original upheaval, all conspire to make the stability of its eastern slope extremely doubtful.

(a) *Topography of the Eastern Slope of Turtle Mountain.*

The notable steepness of the mountain side throughout the part of it which overlooks the town-site is obvious to any observer on the ground. The same quality is apparent to any topographic expert who studies the admirable contour map made under the direction of Mr. Boyd for the Dominion Geological Survey (see Map of Turtle Mountain and Vicinity). A quantitative idea of the average and maximum steepness can also be obtained from an inspection of the profiles (Figures 2-10), taken at regular intervals along the general slope. Finally, the steep quality of the eastern flank is illustrated in the accompanying photographs (Plates II and III), as well as in the cardboard model (Plate IV) herewith submitted.

The following table shows the average angles of slope (measured from the horizontal plane) for 400 foot vertical intervals on each of the profiles (here respectively numbered 1 to 9) shown in Figures 2-10:—

Contour Interval.	1	2	3	4	5	6	7	8	9
7000-6600	....	......	. . .	.....	56°	67° (200 ft.)	66° (220 ft.)	62° (360 ft.)	55° (500 ft.)
6600-6200	......	......	......	61°	47°	51°	59°	45°	46°
6200-5800	....	. ....	52°	58°	44°	39°	38°	34°	36°
5800-5400	51°	58°	40°	45°	50°	34°	31°	33°	30°
5400-5000	46°	56°	45°	42°	35°	32°	30°	31°	30°
5000-4600	52°	40°	34°	30°	27°	24°	26°	24°	20°
4600-4200	34°	31°	22°	19	18°	22°	23°	22°	13°

The measured angle of rest for the coarse rock-debris in the longest talus slope of Turtle mountain (eastward from a point near the South peak), is just thirty degrees. If a plane of complete scission should be developed in the mountain, and if the inclination of that plane to the horizontal should exceed thirty-two degrees, the block overlying the plane of scission must instantly slide down along that plane. Actual experiment shows that thirty-two degrees is somewhat more than the maximum or limiting angle of inclina-

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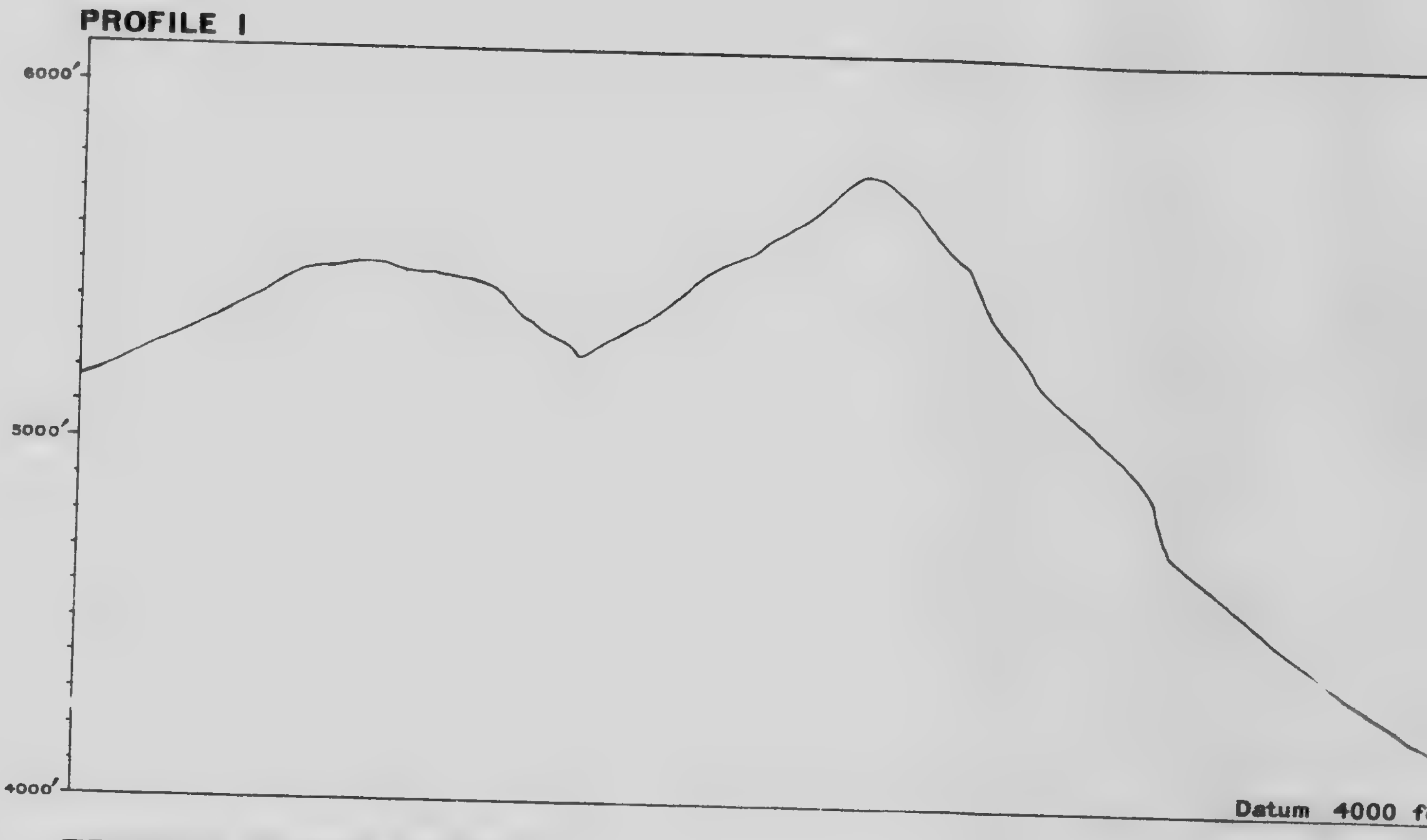


PROFILE ALONG SECTION 1

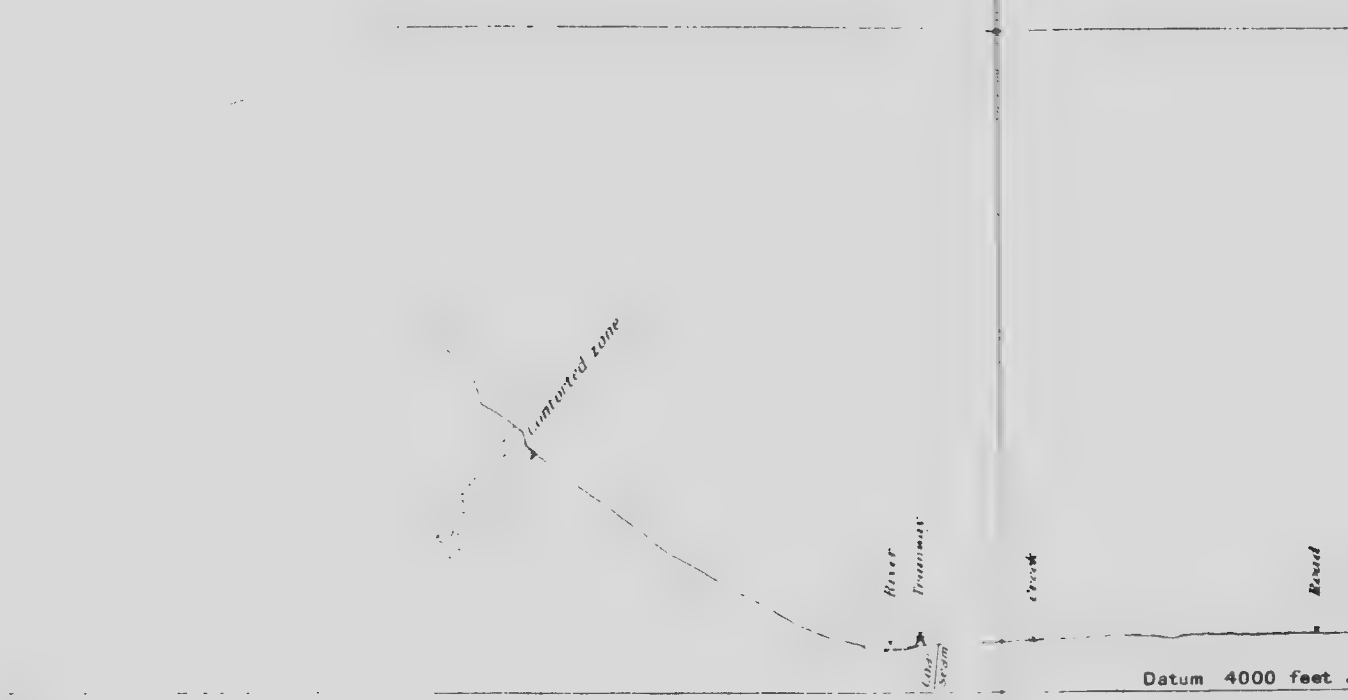
(see accompanying map)

Horizontal and vertica

FIGURE II

, vertical scale, 500 feet to 1 inch

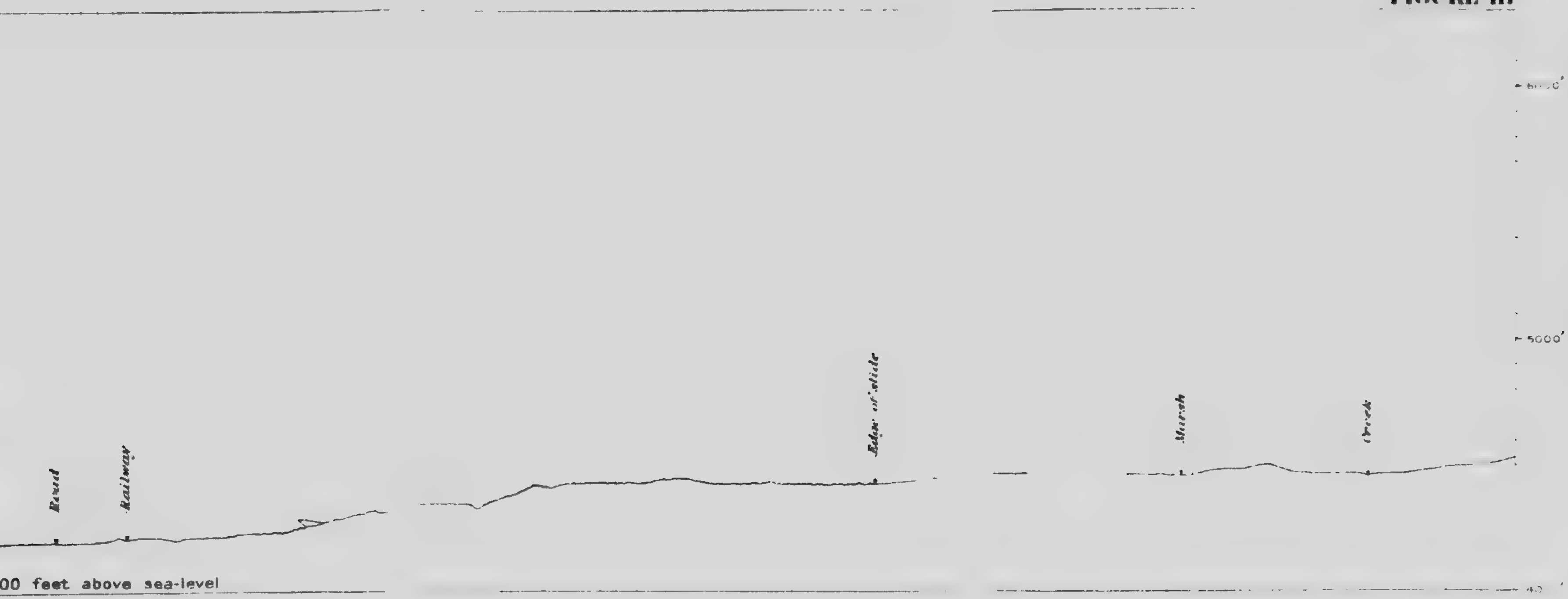
PROFILE 2



PROFILE ALONG SECTION 2

Horizontal and vertical sc

FIGURE III



ertical scale, 500 feet to 1 inch

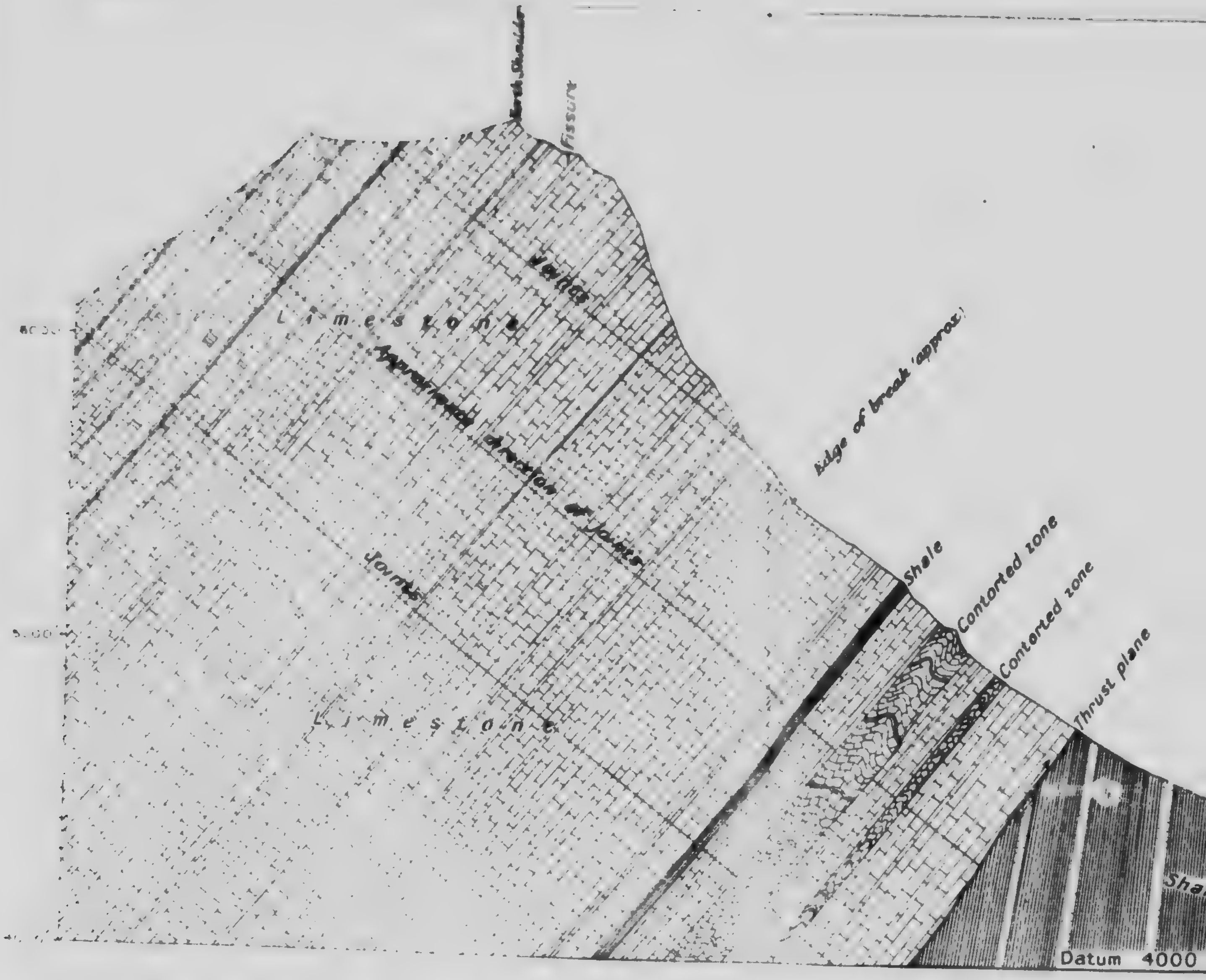
PROFILE 3

PROFILE ALONG SECTION 3

FIGURE IV


7000'
6000'
5000'
4000'
Edge of shale
Road
Railway
00 feet above sea-level
vertical scale. 500 feet to 1 inch

PROFILE 4



PROFILE ALONG SECTION 4

see accompanying [illegible]

DIAGRAMMATIC S

showing geo

TURTLE

Horizontal and verti

FIGURE V

ATIC SECTION ALONG PROFILE
ng geological structure of
RTLE MOUNTAIN

nd vertical scale, 500 feet to 1 Inch

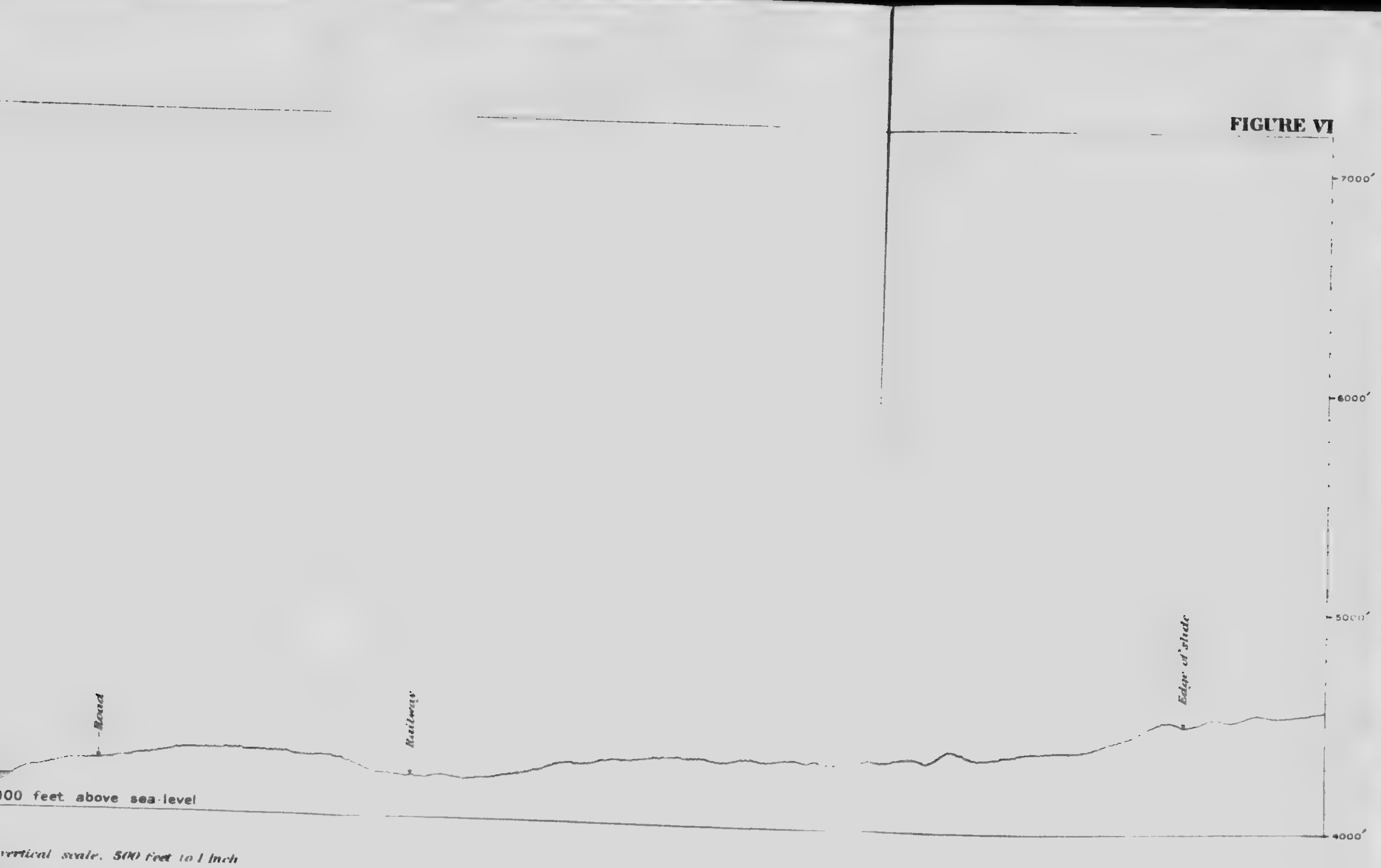
PROFILE 5

PROFILE ALONG SECTION 5

See accompanying map

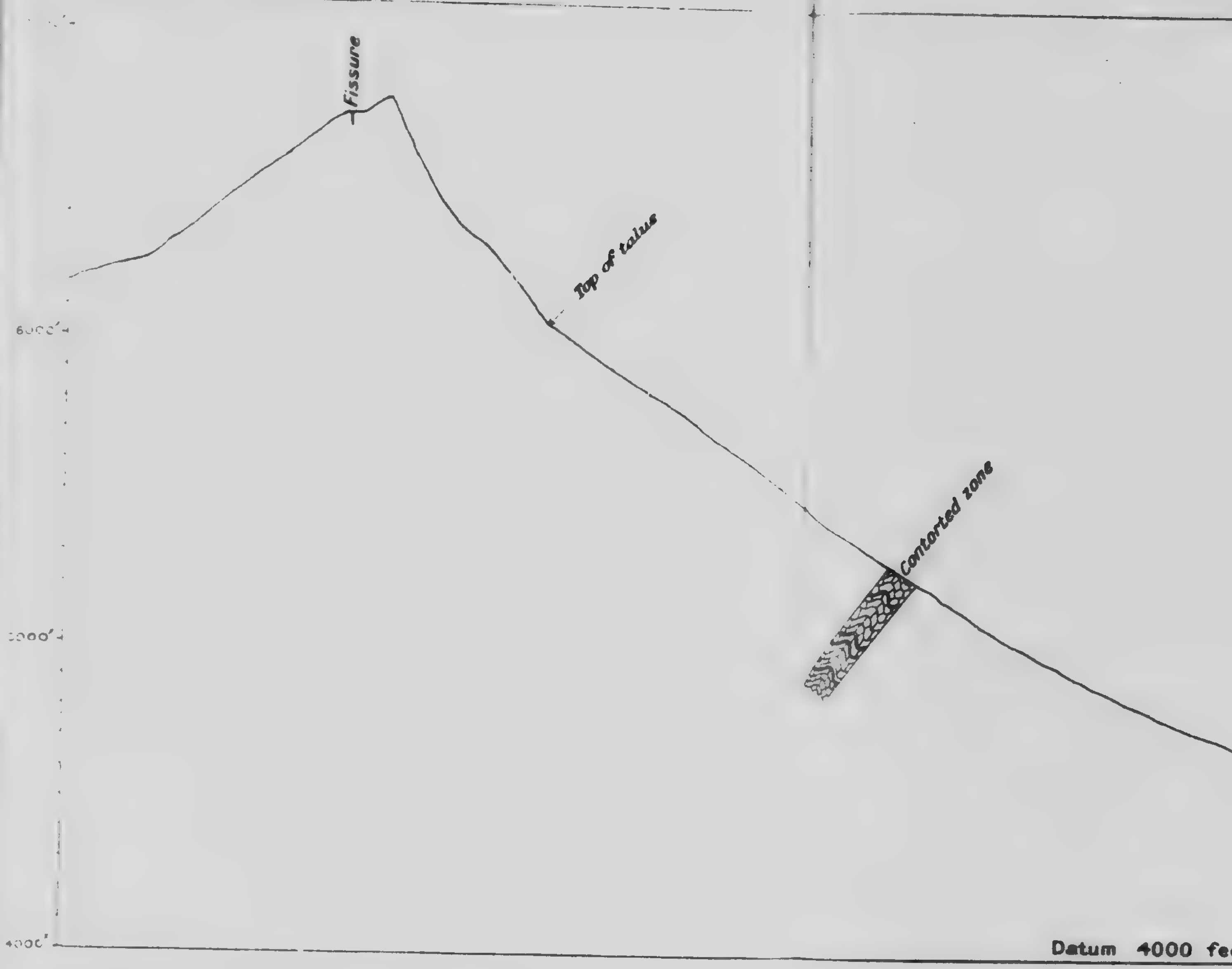
Horizontal and vertical sc

FIGURE VI


7000'
6000'
5000'
4000'
Road
Railway
Edge of slide
feet above sea-level
scale, 500 feet to 1 inch


P
7000′
6000′
5000′
4000′
F

PROFILE 6

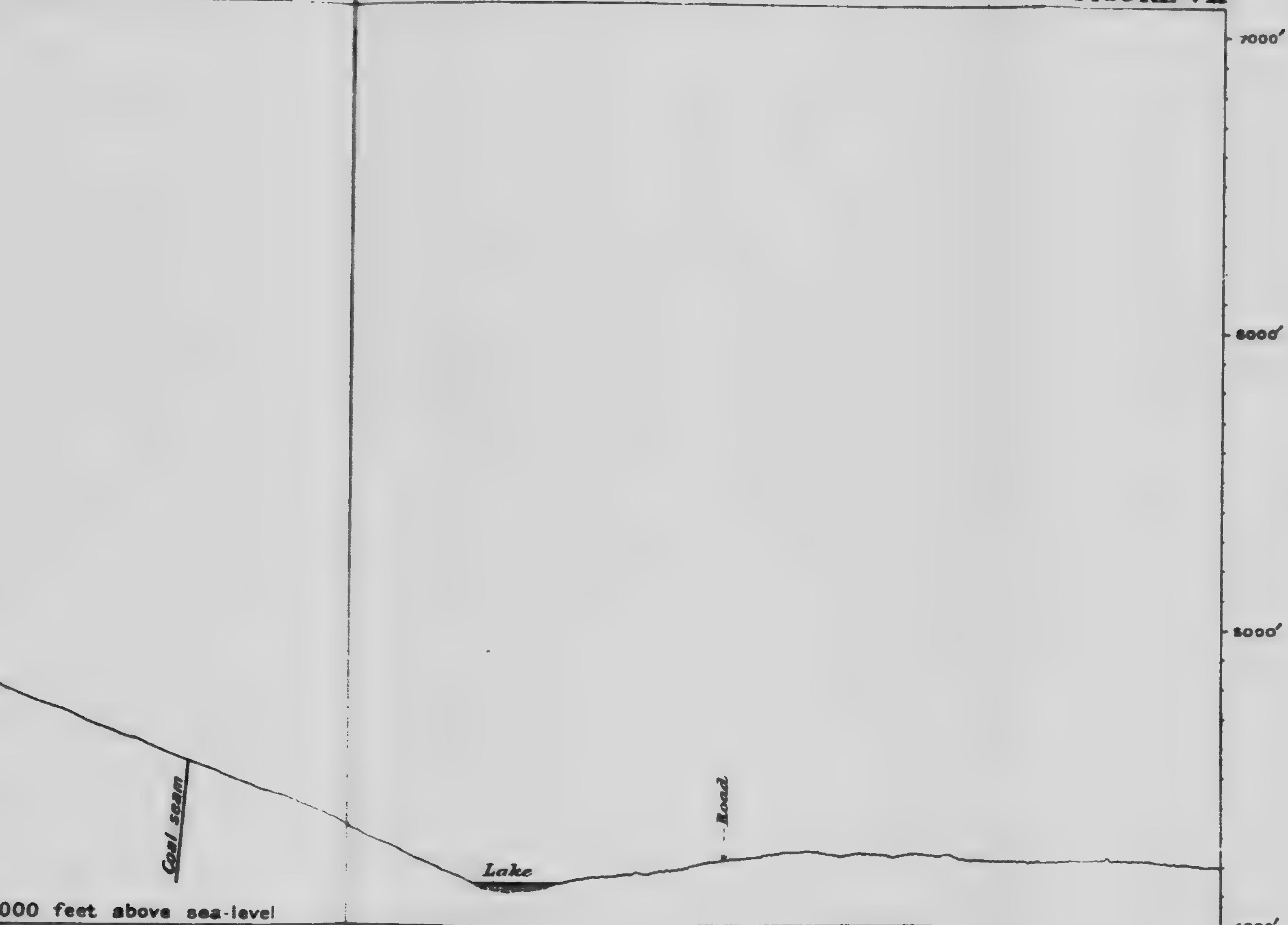


PROFILE ALONG SECTION 6

(see accompanying map)

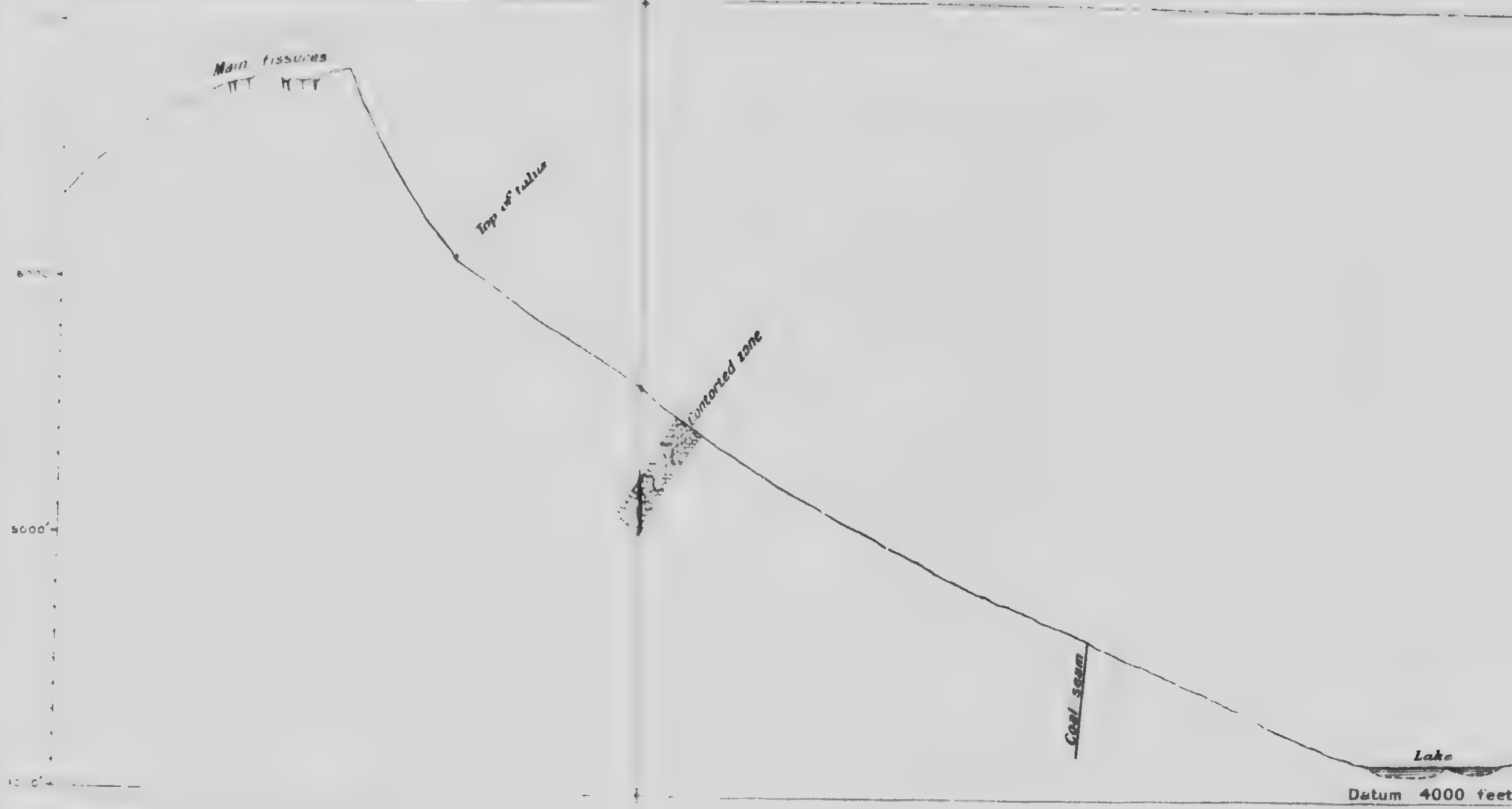
Horizontal and vertical

FIGURE VII



vertical scale, 500 feet to 1 inch

PROFILE 7



PROFILE ALONG SECTION 7

see accompanying map)

Horizontal and vertical s

FIGURE VIII

vertical scale, 500 feet to 1 inch

[illegible]

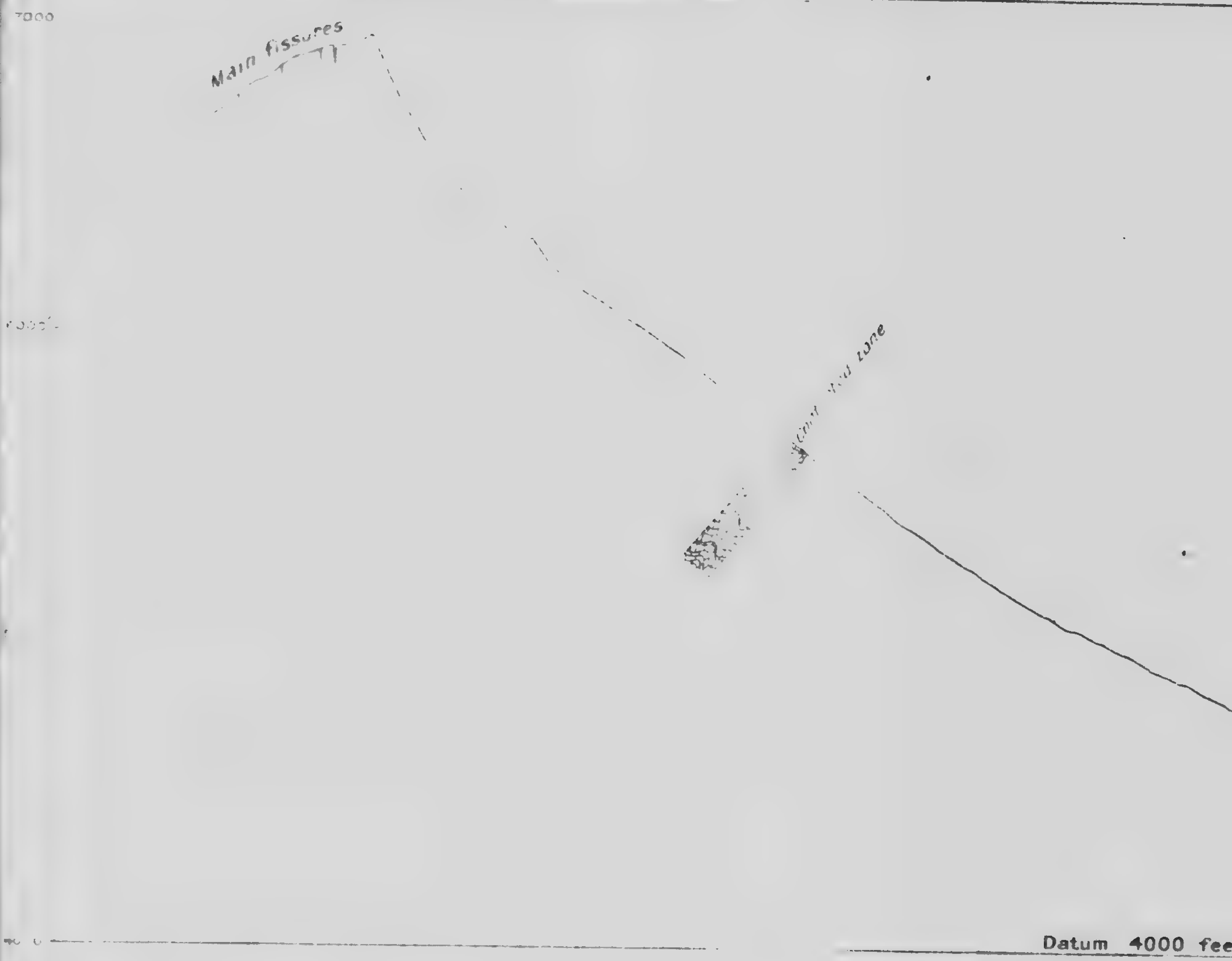
70[illegible]

600[illegible]

500[illegible]

[illegible]

PROFILE 8

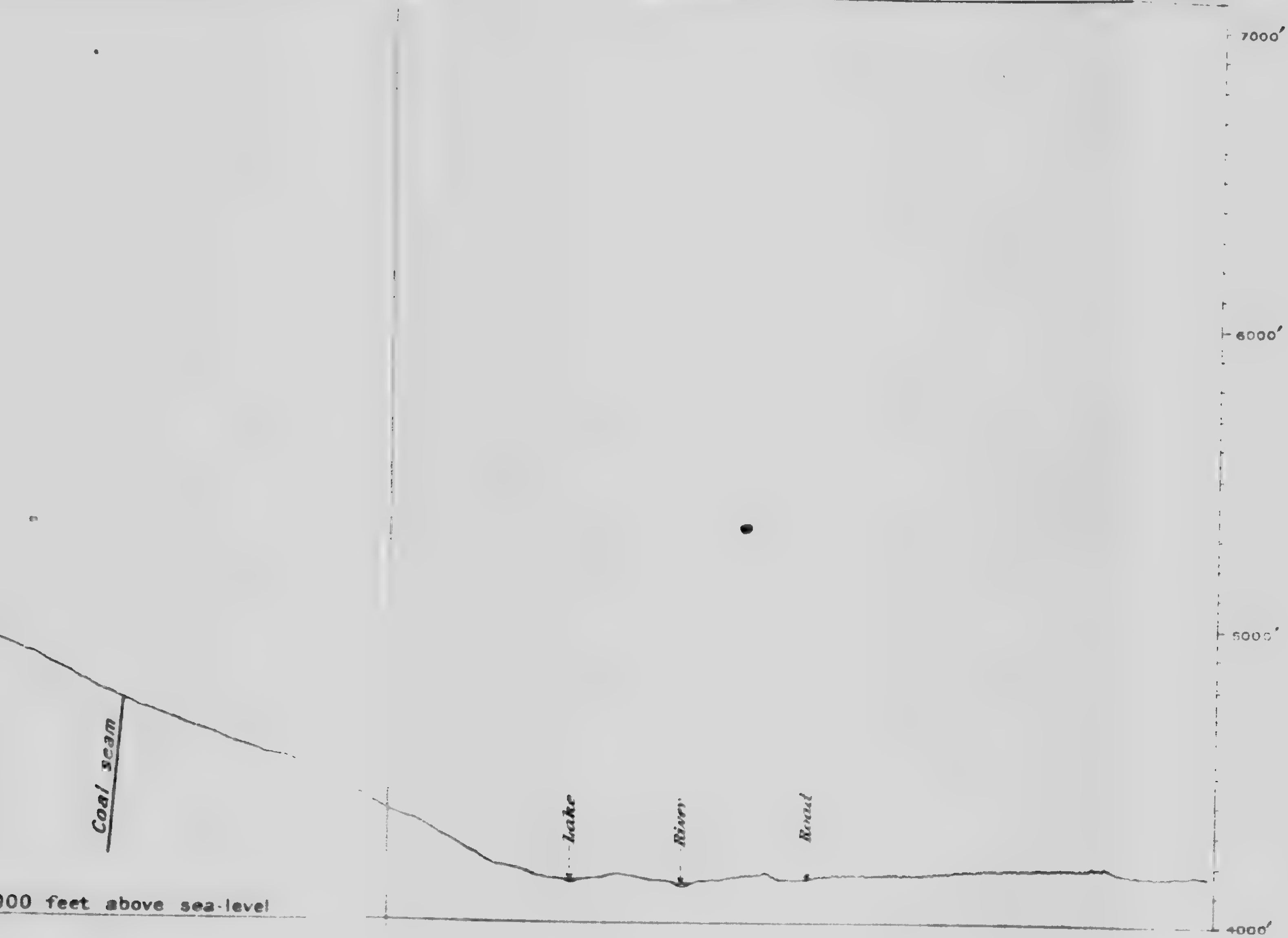


PROFILE ALONG SECTION 8

see accompanying map

Horizontal and vertical

FIGURE IX



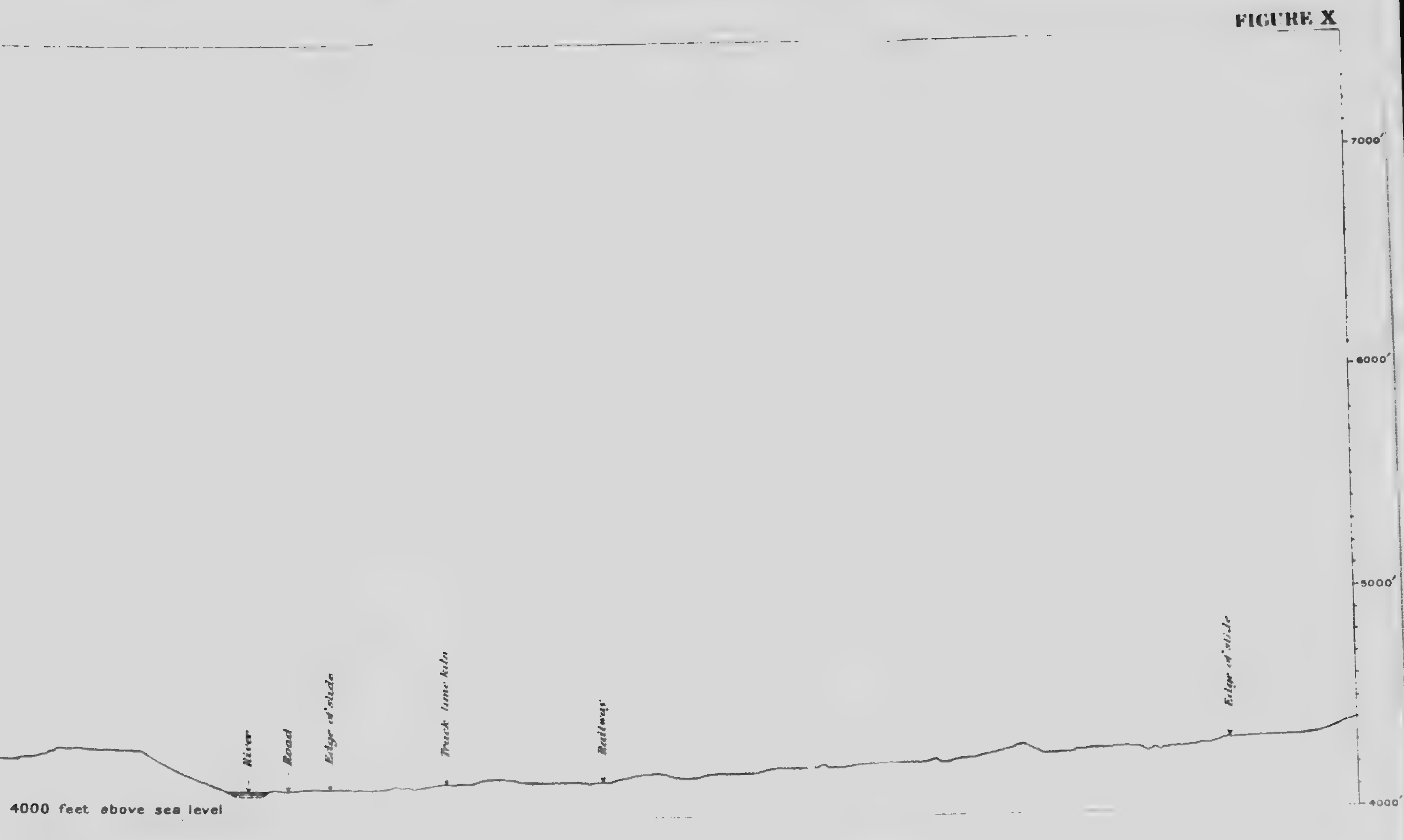
vertical scale, 500 feet to 1 inch


7000
6000
5000
4000

PROFILE 9

Horizontal and vertica

PROFILE ALONG SECTION 9



...d vertical scale, 500 feet to 1 Inch

Looking south over Frank to 1903 slide. The "contorted zones" in the limestone at the base of the "North Peak Block" appear above the smokestack of the Power House.

14447 2

Profile view of the north shoulder of Turtle mountain, directly above the town of Frank.

Photographs of model illustrating the topography and structure of Turtle mountain.

tion for the plane of scission if the mountain is to remain stable in spite of the scission.

Bearing in mind this outside value for the limiting angle, an inspection of the profiles in Figures 2-10 and of the foregoing table will suggest the maximum amount of rock matter which could fall from Turtle mountain. It is safe to conclude that much of Turtle mountain lies above a possible plane of scission inclined eastward at the critical angle.

(b) *Geological Structure of the Mountain.*

If Turtle mountain were composed of homogeneous granite or non-jointed limestone, the foregoing calculation would have no practical value; the strength of such rock would be such as to make absurd any reference to the critical angle above defined in connexion with the problem of the mountain's stability. But Turtle mountain is peculiar in possessing a structure which forbids our placing an estimate of an absolutely safe angle for the eastern slope at much greater than thirty or thirty-five degrees. By this, your Commission does not mean to imply that all of the rock bounded by slopes greater than about thirty-five degrees is in danger of sliding before the ordinary processes of erosion have lowered such slopes. Such a danger is, in their opinion, remote, except in a limited area where structural weakness is combined with steepness of slope in a manner to threaten disaster to the town.

Much additional work needs to be done before the geology of Turtle mountain is understood in all its details. The officials of the Dominion Geological Survey have, however, elucidated the structure to an extent sufficient for the needs of the present problem. So far as it has had opportunity in the field to test the main conclusions of the government geologists, your Commission is in agreement with these gentlemen. The structure of the mountain is indicated in the section, Figure 5, which has been adopted from their reports. This section is taken along the accurate profile No. 4 constructed for the Commission by Mr. Boyd.

In brief, Turtle mountain is an erosion remnant of a great block of Palæozoic (chiefly Carboniferous) limestones overthrust eastward upon the western limb of a syncline of Mesozoic (chiefly Cretaceous) shales, sandstones, and coal-beds. The average dips of the beds in these two primary divisions of the mountain are

shown in Figure 5. The thrust-plane is located in the section with fair accuracy, but its exact inclination to the horizontal plane is not apparent in the outcrops. It is the opinion of the government geologists that the thrust-plane is highly inclined and accordingly it has been so drawn on the section.

From the river flat to the lower contact of the limestone (that is, the outcrop of the thrust-plane), the mountain slope is underlain by soft shales, interrupted by coal-seams and by some interbeds of sandstone. The whole is an unusually weak mass of rock; yet forms the basal abutment which is to-day helping to sustain the heavy limestone forming the upper half of the mountain.

Weak as this lower member is, it might continue to hold up the entire slope if it were not for the inherent weakness of the limestone itself. The latter is composed of rapidly alternating beds of contrasted nature. Some of them are thick, massive, and coherent, and, if the whole upper member were constituted of similar material, the chance for a destructive slide in the future would be greatly lessened. But very many other beds are flaggy, easily split along the bedding-planes and, therefore, far less strong than the beds just mentioned. On this account alone the average strength of the whole limestone member is much below that of many, perhaps most, of the great limestone formations of British Columbia or Alberta. In addition, the total strength of the member is seriously lessened by the presence of two zones of crumpling within the mass. These zones are diagrammatically shown in the section, Figure 5. It should be carefully noted that the lower edge of the mass which fell in April, 1903, coincides with one of these contorted zones. That event actually illustrated the profound weakening of the mountain structure because of the presence of these zones. Another source of weakness is found in a band of soft shales, which breaks the continuity of the limestone (See Figure 5).

However, the chief reasons for concern as regards this matter of rock strength, are the heavy jointing of the limestone and the relation of the joints to the eastern slope of the mountain, the side facing the town. As is so often the case with sedimentary rocks, very abundant joints occurring in several systems are developed nearly or quite perpendicular to the bedding. The dip of the bedding is always westward and varies from 65° to 50°. At the North and South peaks, and for a considerable distance north of the North peak (that is, the part of the mountain opposite the

PLATE V.

Looking northward along one of the larger fissures in the limestone on Turtle mountain. The limestone on the right has slipped down fifteen or more feet. The fissuring and slipping (faulting) were clearly facilitated by the joint-planes, some of which appear in the photograph. The North peak is seen in the upper right-hand corner.

PLATE VI.

Looking north along a main fissure between the North and South peaks. The trees show strong movement of the limestone block on the right of the fissure.

Looking north to North peak along a main fissure which is exposed for 1,500 feet.

Looking north to North peak over the fissure area.

View of the fissured area looking north from South peak.

PLATE X.

Detail of a main fissure in the limestone.

PLATE XI

A main fissure produced like the others shown in previous plates by the pull exerted on the mountain top during the 1903 slide.

A part of the fissured area taken with a levelled camera. The movement of the limestone in 1903 is indicated by the attitude of the trees.

town), the average dip is about 50° to the west. This means that many of the joints mentioned dip directly eastward at an angle of 40°. Other systems of these joints dip towards the northeast and southeast quadrants at still higher angles. The relation of the easterly dipping joints to the topography is illustrated in Figure 5. The diagram is intended to make clear this highly important cause for instability in the mountain. If the dip of the bedding were notably *steeper* than 50°, the easterly dips of the joints would be correspondingly flatter, and the danger of bodily slipping along that joint system would be materially less than under the present conditions. If the dip of the bedding were notably *flatter* than 50°, the easterly dips of the joints would be correspondingly steeper and continued spalling of small blocks along those joints would have produced a steep but stable profile for the mountain in prehistoric time. The actual dips of the bedding and joints are almost ideal for the production of great intermittent slides from a mountain with the steepness of Turtle mountain. The slipping on joint-planes during the slide of 1903 is illustrated in Plates V and VI.

The joints are thus of profound importance as they so seriously affect the strength of the limestone and, by their attitude, furnish potential slipping planes, which threaten to become actual slipping planes if a heavy jar or a disturbance of the basal abutment should occur. Moreover, joints are the favourable channels for the seepage of ground-water which tends slowly to enlarge them and also to wet the rock, increasing the danger of sliding *en masse*.

As a result of the 1903 slide, many profound fissures were opened on the North and South peaks, and in the part of the summit area between the peaks (Plates VII-XII). These are partly due to a powerful pull exerted by the huge rock prism as it fell outward and downward. These fissures are as noteworthy for depth as they are for extent along the surface. In general, they run nearly parallel with the edge of the main eastward-facing escarpment, i.e., that overlooking the town. They not only show movement of vast masses of rock towards the brink, but they also represent deep openings into which surface water from rain and heavy snow must run, and at certain times of the year be frozen at the bottom of each fissure. It is impossible to say exactly what effect this action may have in the future, but there is evident danger of the wedging out of huge prisms of rock through frost action. That displace-

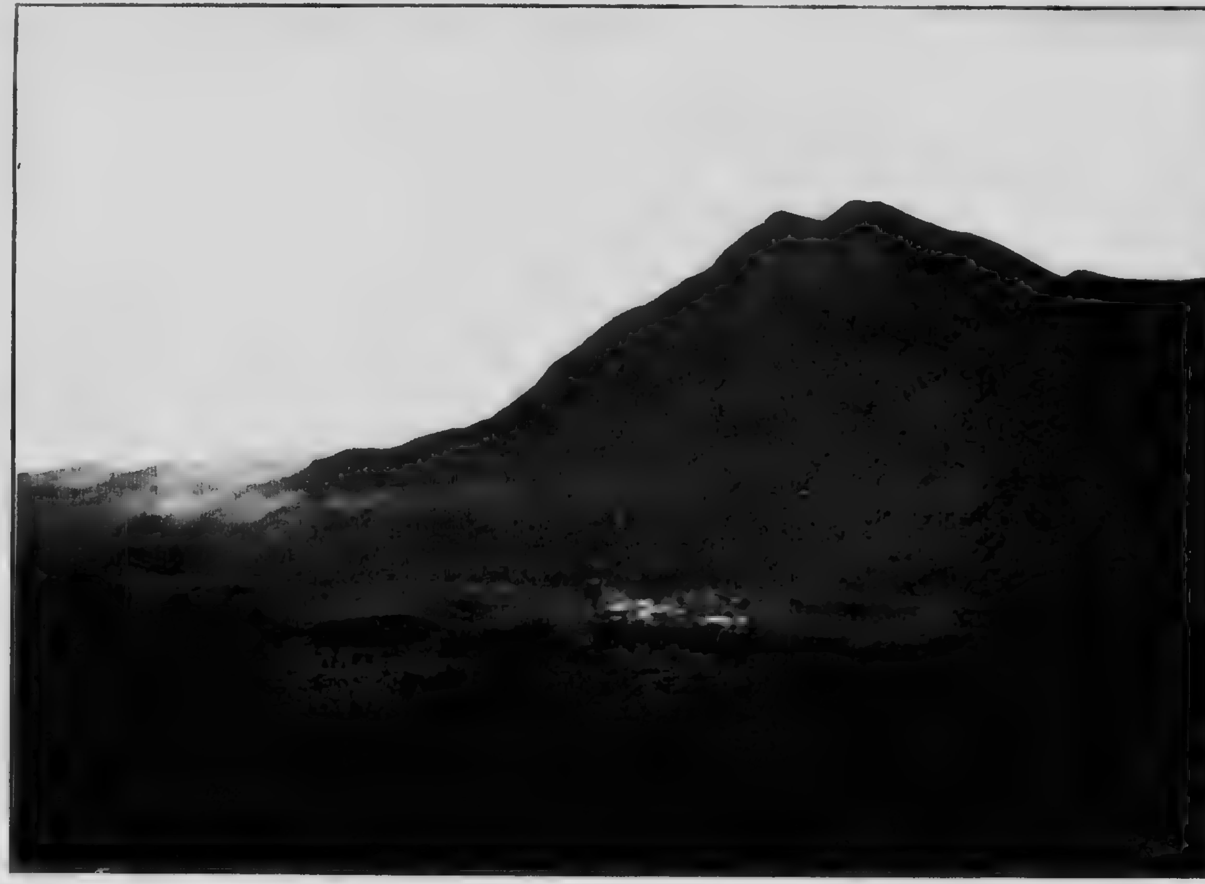
ment may directly cause considerable falls of rock or so disturb the delicate mechanism of the mountain as to initiate slipping on master-joints, and thus even a landslide of the first order.

(e) Influence of Strains Developed during the Period of Overthrusting.

Another special condition tending to make the mountain unstable is a result of the peculiar mechanism by which this particular mountain ridge was originally uplifted. The limestone member was not pushed up directly from beneath, but, as agreed by all competent observers, was thrust over the coal measures and the underlying Fernie shales. The almost inconceivable force which was necessary to accomplish that result must have developed compressive and tensional stresses throughout both overthrust and underthrust members. By far the greater part of these stresses have, of course, been relieved by massive and molecular changes in the mountain during the ages elapsed since the mountain-building period. But a percentage of the total stresses may still remain in the existing erosion ridge, i.e., Turtle mountain. This proportion of residual stresses may be very small and yet sufficient to cause the spalling-off of huge slices of rock from the steep eastern face, if other conditions are favourable. Cases of such exfoliation of rock through mountain-building stresses (strains) have been recorded in the much older mountain system of New England. Similar stresses are not to be expected in flat-lying coal measures which have not suffered the powerful strain of mountain-building overthrust.

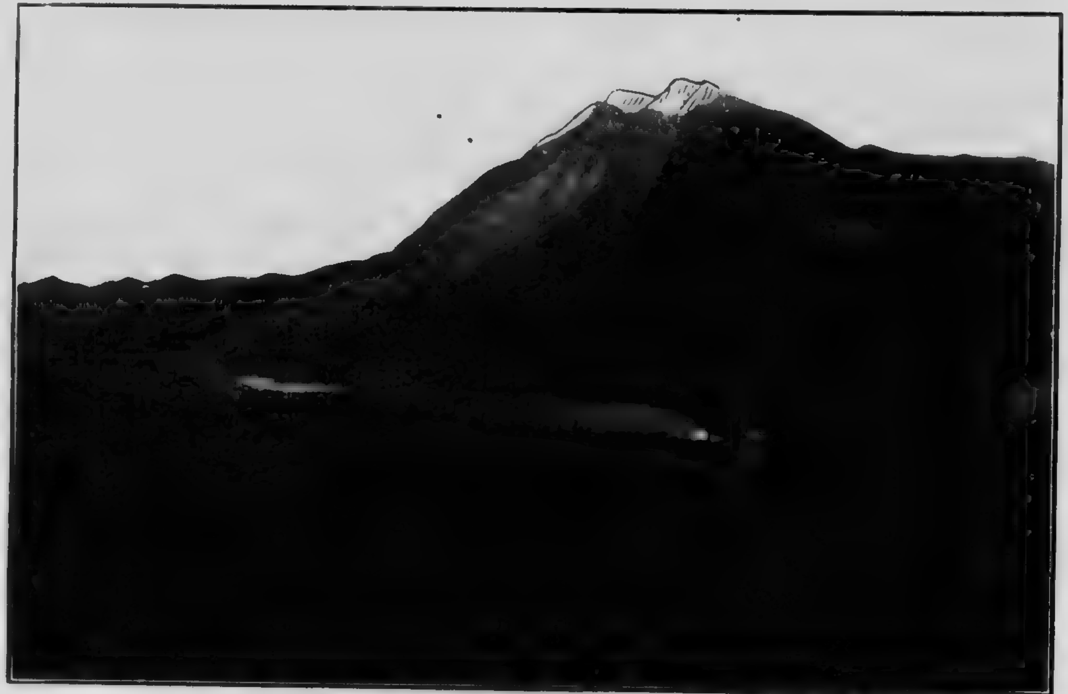
(2) EFFECT OF VIBRATION.

In view of the many special conditions which together render this mountain liable to heavy slides—particularly the existence of eastwardly-inclined joint planes—a general condition to which all mountains are exposed must be seriously taken into account. We refer to the dangerous effect of vibration. A very moderate earthquake, such as that of 1901 in this region, might precipitate a slide of the first order. A strong jar communicated by a quite moderate settlement in the mine workings at Frank might have a similar result. Vibration caused by blasting at a railway cut in the town was found to affect the stability of the mine workings, a few hundred feet distant. The latter fact suggests that, to be so affected by such moderate jarring, the rock, which here represents part of the



View of Turtle mountain before 1903 slide, from a point 3,100 feet northeast of the smelter building.

PLATE XIV



View of Turtle mountain in October, 1911, taken from the same point as Plate XIII. The block which broke away in the 1903 slide is shown in outline.

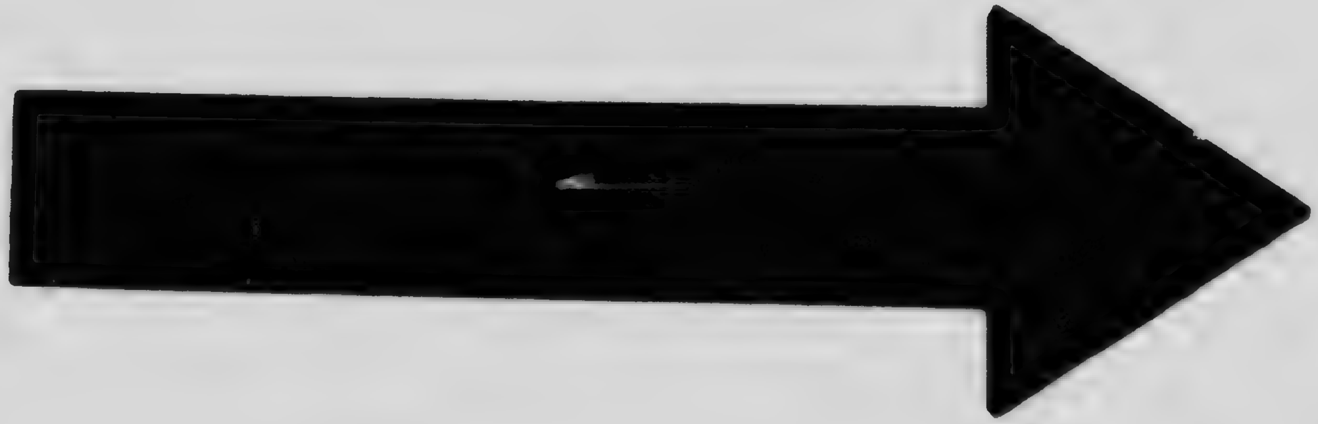
PLATE XV.

s east of the railway station.

PLATE XV.

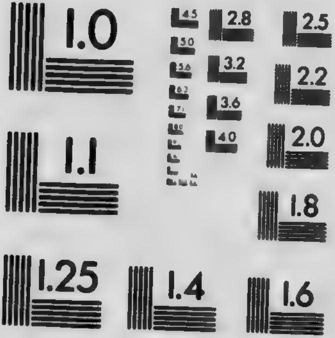
View of Turtle mountain before the slide of 1903, taken from the bluff two hundred yards east of the railway station.

14447—6



MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)



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1653 East Main Street
Rochester, New York 14609 USA
(716) 482 - 0300 - Phone
(716) 288 - 5989 - Fax

View of Turtle mountain in October, 1911, taken from the same point as Plate XV.

basal abutment of Turtle mountain, must be under quite ... stress, as if feeling an outward thrust from the foot of the mo... In estimating the effect of a strong jar it must also be remembered that Turtle mountain is a sharp ridge and, therefore, more readily shaken as a whole than if it were dome-shaped or plateau-like.

(3) Natural Conditions of Turtle Mountain Nearly Similar to Those Preceding the 1903 Slide.

It is clear that the structure of the mountain is essentially the same along all profiles from the south side of the South peak to a point at least one-half mile north of the North Peak summit. To that whole stretch the foregoing statement of serious structural weakness will apply.

On the other hand, the evidence is strong that the average original slope on the face of the rock prism which fell in 1903 was very similar to the average eastern slope of the mountain for a long distance north of the original site of that prism. Your commission had so concluded, in a preliminary way, as a result of an early study of Plate I in the McConnell-Brock report. This was reproduced from a poor photograph showing Turtle mountain before the slide (See Plate XIII of the present report). Under our direction a second photograph was taken from the same spot on October 9 of this year. This appears as Plate XIV in this report. A much more convincing exhibit of the topography before and after the 1903 slide is given in Plates XV and XVI. Plate XV is a copy of a photograph discovered in Frank during our visit, and shows the state of the mountain not long before the 1903 disaster. Plate XVI is a photograph taken under our direction from the same point.

The comparison of these photographs has corroborated your Commission's opinion that, so far as steepness of slope alone is concerned, the large block culminating in North peak is nearly or quite as liable to fall as was the rock prism which actually fell in 1903.

Your Commission is, therefore, of opinion that, on account of similarity in both topography and structure, the liability of a first-order slide at the present North peak is made the more probable because a disastrous slide did take place, in 1903, just to the south.

(4) Weakening of the North Peak Block as a Result of the 1903 Slide.

Not only is the 1903 slide an indication of the ultimate fate of the North peak; it has itself prepared special conditions for a disastrous slide from the North peak. The contour map (see Map of Turtle Mountain and Vicinity), and the photographs (Plates II and IV), show that the removal of the great rock prism by the slide of 1903 has left the southeast flank of the North peak unsupported. In that respect the North Peak block has been left in greater danger of sliding than before the 1903 disaster, though it is impossible to say how far the danger of the sliding of the North Peak block has been lessened by the removal of a possible tensional stress exerted by the great prism which actually fell out in 1903.

Moreover, it must not be forgotten that enormous blocks of rock were torn apart in 1903, and that very great falls from the fissured region between the two peaks may occur at any time. Such a rock fall, though itself harmless for the town, might jar the mountain so effectively as to precipitate the North Peak block and thus indirectly bring disaster to the town.

(5) Evidence of New Cracks Showing Movement of the North Peak Block.

Your Commission found two considerable fissures opened in the rock of the North peak within recent years. One of these, a few inches wide at the surface and visible for a distance of about 50 feet, occurs on the eastern slope of the "North shoulder" about 680 feet, N. 26° E., from the North Peak summit triangulation signal, and on the 6,620 foot contour. We found no independent means of dating this fissure, which may have been opened at the time of the 1903 slide, and since enlarged, as stated by Mr. Brock in the letter of November 3, 1910, quoted above. The other fissure, with an average width of about five inches where visible, occurs at a place about 300 feet, N. 19° E. of the North Peak summit station (see Map of Turtle Mountain and Vicinity), and about 40 feet from the brink of the precipice overlooking the town. Adhering to the wall of this fissure your Commission found rootlets of plants which had taken root in the fissure evidently before it had enlarged to its present width. The original fissure may well have been a joint-plane slightly enlarged by solution or else by an ancient slight

movement of the rock. The rootlets were so delicate that it was clear they could not have failed to rot away or to be washed away within a very few years after the enlargement of the ancient fissure. Adhering to these rootlets was a quantity of black soil. This soil was only three or four inches below the top of the fissure, where it was liable to be readily washed away by rain or by running snow-water. It was particularly the discovery of this soil about delicate rootlets still in place, which has convinced your Commission of the recency of this particular fissuring or widening of a fissure. Our impression is that this widening took place within a period not greater than two years.

Owing to the frost-riven character of the summit slopes of the mountain, it is practically never possible to trace the new fissures (tho formed during and since 1903) for their full length. For the same reason it is certain that only a fraction of the total number of fissures can be actually seen. Further search for them and continued observation of those found are highly desirable.

Your Commission endeavoured to find the plat or instrumental record of a survey of bench-marks reported to have been made just after the 1903 slide. These marks were set among the North Peak fissures for the purpose of noting movement of the rock. Our information regarding the survey was taken from an article by Walter E. Dowlen in the Engineering and Mining Journal, July 4, 1903. However, we have been unsuccessful in our search at the office of the Canadian Coal Consolidated, Limited, and elsewhere; accordingly, this method of observing any progress of rock-movement since 1903 could not be applied.

For future guidance, it is desirable that monuments be established in the vicinity of the crevices, so that any movement may be accurately measured.

The reasons for concluding that, irrespective of mining operations and because of existing conditions only, there is danger of a disastrous landslide from Turtle mountain, are summarized at the end of this report.

B. Influence of Mining on the Stability of Turtle Mountain

THE PROBLEM.

As shown on a preceding page, Messrs. McConnell and Brock, in their report on the great slide of 1903, considered that the

mining operations conducted at the base of Turtle mountain might have been a contributory cause of starting that slide.

In the summary reports of the Geological Survey of Canada for 1909 and 1910, the Director stated that continuance of mining within certain areas, termed danger zones, might cause further land slides which would endanger the town of Frank.

The limits of these danger zones formed the subject of correspondence between the Director and the representatives of the Alberta government; and the Director indicated on a map of the mine the limits of the zones.

Your Commission has carefully weighed the evidence presented in the reports mentioned and also such informal evidence and suggestions as have been given by those who had knowledge of the mine and of the condition of Turtle mountain, both before and after the great slide of 1903. We have also entered and studied accessible parts of the two mines at the base of Turtle mountain.

The relation of the mining to the past and present danger of landslides from Turtle mountain may be considered under two heads:—

(1) What effect might mining have had in causing the slide of 1903?

(2) Is it probable that continuance of mining will cause other great slides?

The latter is a vital question, but it is necessary to consider the former in order to determine, as far as possible, how nearly the present conditions surrounding mining are analogous to those prior to the slide of 1903.

LOCATION OF THE FRANK MINES.

There are now two mines operating along the foot or east base of Turtle mountain, a shaft mine and a drift mine. Both belong to the Canadian Coal Consolidated, Limit[illegible] merly belonged to the Canadian-American Coal and Co[illegible]

The drift mine was started in 1901 [illegible] mine was not begun until several years after the landslide.

The drift mine enters the outcrop of a nearly vertical coal seam at a point 27 feet above the present level of the Crowsnest (Oldman) river. The strike of the seam is nearly north and south, parallel with the general axis of Turtle mountain, though not

[illegible]

[illegible]

4000

3000

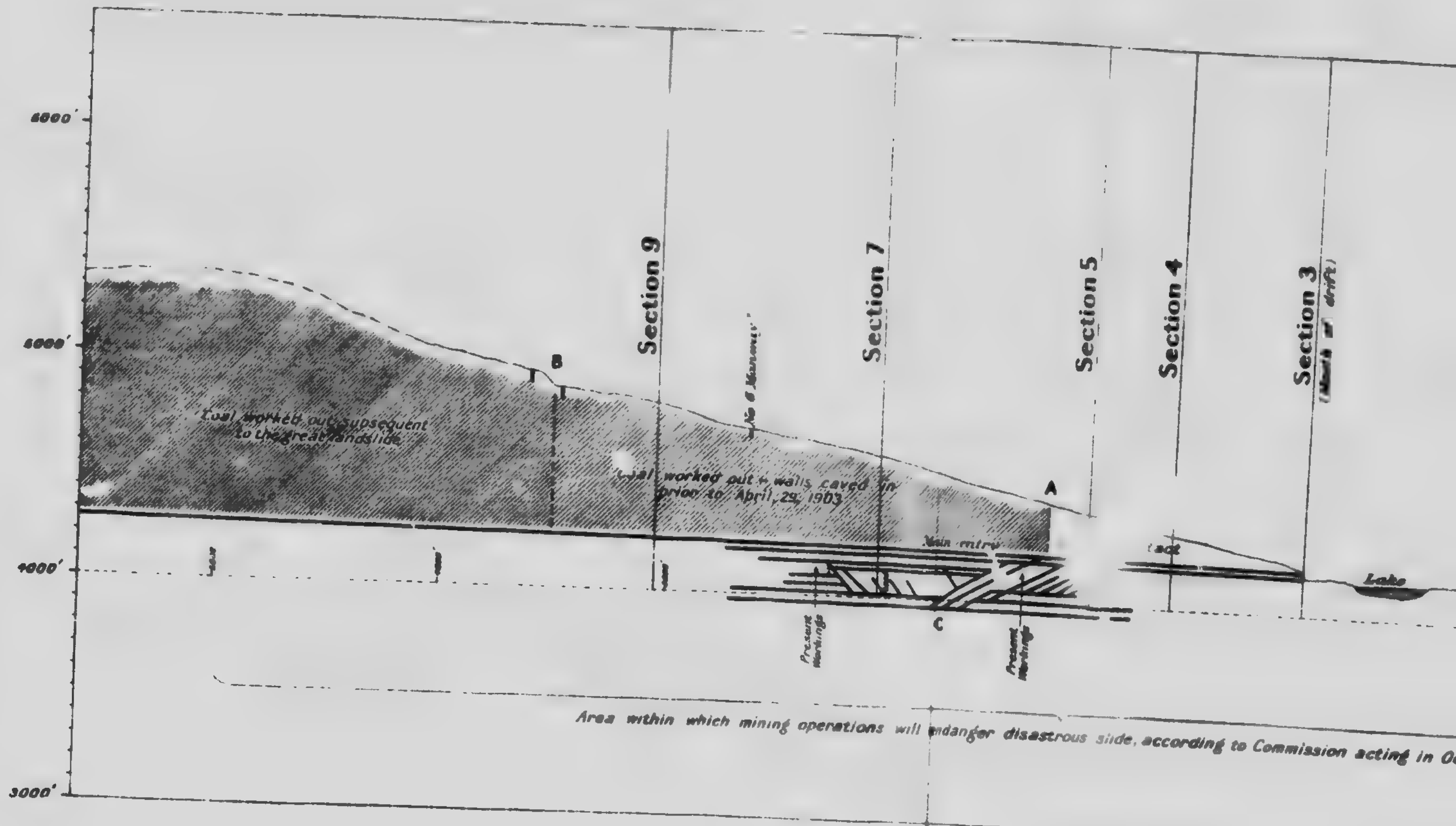


DIAGRAM SHOWING

of mine

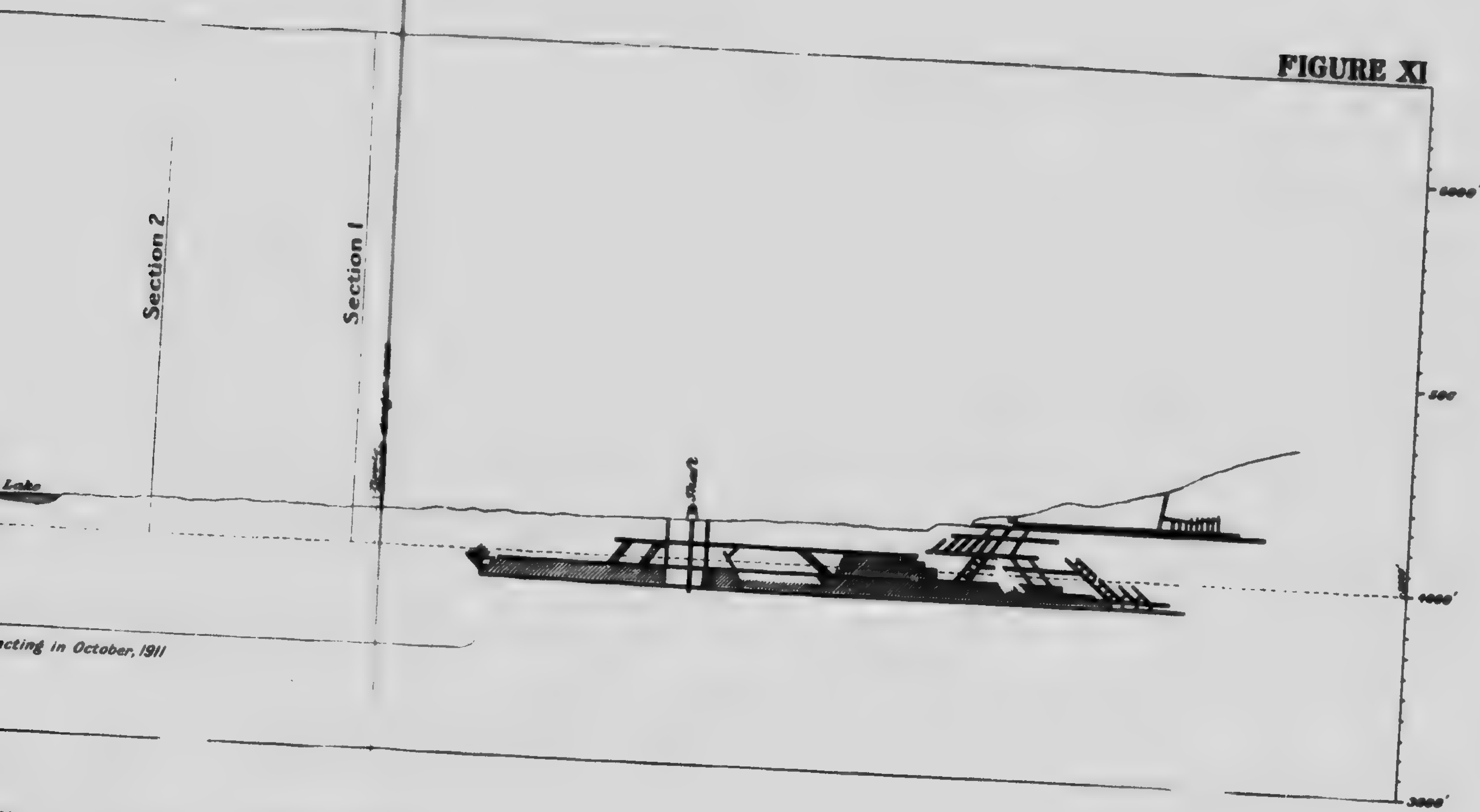
CANADIAN COAL C

FRA

ALB

Horizontal and vertical

FIGURE XI



WING VERTICAL PROJECTION
mine workings of
DAL CONSOLIDATED, LTD.
FRANK
ALBERTA

vertical scale, 800 feet to 1 inch

with the base of its easterly slope, which trends to the west of north. In going south from the mouth of the drift mine the outcrop line crosses an easterly spur of the South peak of the mountain, rising to a height of twelve hundred feet above the mouth of the drift. In a northerly direction from the mouth the outcrop traverses the relatively flat valley of the Crowsnest river. Thirty-eight hundred feet from the mouth of the drift this seam, or possibly a parallel one, is opened by the hoisting and air shafts of the new mine. Twelve hundred feet north of the shaft the north edge of the valley is reached, and the outcrop rises rapidly on the flank of Bluff or Goat mountain. A level enters this part of the outcrop about 20 feet above the valley; it is connected underground with the shaft-mine workings. The shaft mine and the original drift mine are not connected underground; there is a distance of 2,700 feet between their nearest workings. The relative positions of the various mine workings are shown on the vertical, longitudinal profile along the outcrop of the coal seam, in Figure 11.

COAL SEAM DEVELOPED BY THE MINES.

It is not known whether the two mines are in the same coal seam. That opened by the drift mine is from ten to fifteen feet thick, has a hard sandstone roof and a hard, thin-bedded shale floor, which through overturning have become the foot and hanging wall respectively. Forty feet below this seam stratigraphically, there is a two-to-four-foot dirty seam, which is unworked.

The dip of the seams is from 82° to 90°, with an average of 85°, to the west; the seams, therefore, dip towards Turtle mountain.

The coal developed by the shaft mine is thinner, six to ten feet thick, and it is said to have a higher content of volatile matter, but the roof, floor, and other characteristics are the same.

There are said to be other seams both above and below the main seam, but they have not been definitely exposed by prospecting. It is thought that the Hillcrest mine, which lies immediately south of the Frank mine, may be operating on a different seam. At the Bellevue mine on the opposite side of the valley of the Crowsnest river and on the east limb of the syncline, four seams are known, two of which (in some places a third) are workable. The existence of other workable seams at Frank is of importance, for if it is conceded that mining operations in one seam may favour slides, it

must be admitted that operations in additional seams above or below would increase the risk. In the absence of definite knowledge, the discussion must be confined to the operations in one seam only.

RELATION OF OPERATIONS IN THE DRIFT (No. 1) MINE TO THE LANDSLIDE OF 1903.

At the time of the landslide of 1903, the workings in the drift mine consisted of the level gangway, driven in 5,500 feet on the strike of the seam, a level for drainage and ventilation immediately below the gangway, and a series of chambers or breasts driven directly up the raise. According to the 1903 report of Messrs. McConnell and Brock, the chambers were from 60 to 150 feet in width, separated by pillars 40 feet in width. Witnesses before your present Commission stated the average width of chambers was 100 feet, and of pillars 30 feet. Manways and timber chutes four or five feet square were made alternately in the pillars. As the chambers were filled with broken coal, which was drawn off from time to time, the whole mass sliding, no propping between the foot and hanging wall was possible. The series of chambers commenced at or near a point 1,200 feet in from the mouth of the mine. Beyond a point 3,500 feet from the mouth, chambers had merely been started.

A profile of the outcrop and gangways was made from data furnished by the recent Dominion government survey (see Figure 11). This indicates that, if the chambers between the 1,200 foot point and the 3,500 foot point extended to or nearly to the outcrop, they varied in height from 200 feet to 500 feet.

Witnesses appearing before the former Commission stated positively that a squeeze of the walls of the seam was apparent prior to the landslide. Certain persons who appeared informally before the present Commission confirmed this, and one who had been engaged in timbering said that the gangway and manways had to be retimbered several times, the timbers giving way by squeeze from the walls. He also stated that certain manways driven up to the outcrop had been condemned on account of the impossibility of keeping them timbered. A number of the witnesses have stated that for a couple of months before the slide, coal had been drawn rapidly from the chambers and that falls from the walls had taken

View of lower part of area devastated in 1903, taken from north spur of Turtle mountain. This photograph illustrates the formation of terminal lobes produced by the "splaying" of the material in a great landslide.

place. In this their testimony agreed with that of others interviewed by the 1903 Commission. Considering the unusual width of the breasts and the impossibility of retaining props ten to fifteen feet long between the nearly vertical walls in a mass of moving coal, it is not surprising that there should have been falls from the walls when the support given by the loose coal was withdrawn.

One witness before this Commission stated that he had investigated the breasts of some of the chambers and found that so much rock had fallen from the hanging wall (west wall), that this wall was undermined or "undercut" to a considerable distance.

The Department of Mines of Alberta reports the following out put from the drift mine:—

1901	15,000	tons.
1902	160,000	"
1903	101,591	"
	276,591	"

The figures for the individual months are not available, but it is reported that the mine prior to the landslide of April 29, 1903, was putting out from 1,000 to 1,100 tons per day. It is also stated that little coal was mined in 1903 after the mine was re-opened, late in that year. Taking into account the rock removed from the mine and the coal lost in the process of loading outside the mine, of which there would be no record, it is safe to say that the excavation prior to 1903 was equivalent to over 276,591 tons of coal, or 245,000 cubic yards. The chambers, in which most of this excavation was done, extended for 2,300 feet immediately under the slide.

To give due consideration to the influence of excavation in this area, it is desirable to estimate its amount for the region above the level of the gangway. The volume represented in the gangway outside of the area in question, plus the number of cubic yards in the water level, is about 9,000 cubic yards. The amount of excavation in the newly started chambers beyond the 3,500 foot point is conjectural, but, from descriptions of witnesses, it probably does not exceed 10,000 cubic yards. Making these deductions from the total estimated yardage, gives a net of 226,000 cubic yards of excavation immediately under the landslide. In this area, including everything from gangway level to outcrop, if the average thickness of seam is assumed to be 14 feet, there are 536,000 cubic yards.

On the foregoing assumptions we must conclude that 42 per cent of the original volume was mined. It is probable from the observations of witnesses that this percentage is an under estimate of the yield. It is, therefore, on the safe side.

This is equivalent to an average shrinkage of six feet over the entire area involved in this calculation, but as broken rock occupies about 1½ times the space of solid rock, the net shrinkage may be considered to be not over four feet. Eventually, however, the broken rock would be crushed together by the weight of the strata, as has been found in driving through old long-wall packs in operations in various mining districts; so the entire shrinkage in time would be six feet. To be on the safe side we will consider only the more immediate settlement. It is not contended that there was a sudden settlement of four feet over the whole area of a length of 2,300 feet and average depth of 450 feet, but the evidence of witnesses is that a squeeze had started about six months previous to the landslide; and it probably continued for a long time before the final compacting took place.

It is difficult to determine what was the exact result of even a portion of such settlement upon the unstable original North peak, but your present Commission agrees with the findings of the Commission of 1903, that the movement of the walls was instrumental in weakening the supports of the peak and possibly was directly responsible for the landslide. The fact that the part of the mountain which fell in 1903 was exactly opposite to, and corresponded in length with, the area of large chambers, cannot be dismissed as merely a coincidence.

Operations in Drift (No. 1) Mine Subsequent to the 1903 Slide.

Immediately after the landslide, which covered the mouth of the drift and carried away the surface plant, the work of recovery was begun. This took some months, so that comparatively little mining was done until 1904. Thereafter the work was prosecuted vigorously, the gangway was driven ahead, and new workings, chiefly to the south of the slide area, made above the gangway by a different system of mining from that previously used, viz.: driving pitching headings and counter-headings, on inclinations of approximately 45 degrees, and then extracting as much as practicable of the pillars thus formed. This is sometimes called the "diamond" system.

The main gangway has been pushed southward to a total distance of 10,100 feet, measured along the seam to a faulted zone. The distance in a straight line from the mouth of the drift is 9,650 feet.

Several years ago a slope was started from the gangway, 1,270 feet from the mouth of the mine, to run down in the seam on a 30° pitch (see Figure 11). After several delays this reached a point 250 feet below the gangway and thence levels were started north and south with parallel airways above. The north level was stopped by direction of the Alberta Inspector of Mines, after correspondence with the Director of the Dominion Geological Survey, because of the possible existence of a deep buried, gravel-filled water course in the valley, similar to one encountered by mine-workings nearly 300 feet deep at Coleman, a few miles up the valley of Crowsnest river.

The south level has been driven 930 feet where a cross fault has been encountered, probably of moderate displacement.

This level and some workings in the block above it are under the area of the great slide. There is no evidence of squeezing at the present time.

The amount of coal mined from the Drift or No. 1 mine since 1903, as reported to the Alberta government, is as follows:—

	Tons.
1904	75,000
1905	90,000
1906	161,402
1907	135,091
1908	10,222
1909	83,880
1910	65,000
	620,595

This tonnage has been mined in that part of the mine south of the great slide and above the level of the main gangway. It is an area approximately 6,300 feet long, measured along the gangway, and averaged 900 feet in height up to the outcrop.[1]

The seam is said not to average as thick in this general area as it did under the great slide; 10 fe[illegible] is considered to be a conservative figure for the average thick[illegible] On this assumption, the

[1] These figures obtained from mine map.

total volume of the area in question is 2,100,000 cubic yards. Figuring from the tonnage quoted above, there were 548,000 cubic yards of coal excavated, or 26 per cent of the whole area. Inspection of the mine maps indicates that some portions of the area had more than 26 per cent mined out, but there yet remains most of the pillars, besides large blocks immediately under the outcrop.

Since the workings above the main gangway, except in the newer working at the southern end, are not accessible on account of falls, it must be assumed that some movements of the hanging wall must have taken place. Readjustment will undoubtedly continue for some time to come. Movement will of necessity be increased by further excavation. However, for reasons given elsewhere, your Commission is of the opinion that, even if continued mining should cause a landslide from the South peak, which stands directly above these workings, it is not likely to endanger life or property, except in the case of passers-by on the road in the valley or more remotely to the track or passing trains on the Canadian Pacific railway.

Workings in the Shaft (No. 2) Mine.

As mentioned previously, the shaft is located 3,800 feet north of the mouth of the drift mine, and may or may not be working in the same seam. It has been sunk to a depth of 330 feet, and several levels have been driven from it, north and south, the deepest at 330 feet. The south 330 foot level has been driven 1,000 feet from the shaft, and has stopped in a fault, probably of small displacement. Since this level is directed towards the low part of the valley, its further driving has been stopped by the Alberta government for the same reasons as caused the stoppage of the north level from the slope of No. 1 mine, namely, the danger of encountering a buried water channel. North from the shaft the 330 foot level has been driven 2,400 feet. The so-called smelter level, which with intermediate levels is above it, is in advance of the lower levels making the farthest north workings 2,900 feet from the shaft.

As mentioned previously the seam is thinner than that worked by the drift mine; it ranges from 6 to 12 feet thick, with an average of about 8 feet.

The dip is from 85° to 90° to the west. In going north from the mouth of the drift mine, the strike of the seam curves slightly to the east, as shown by the workings and by the outcrop where it

View of Bluff (Goat) mountain looking northward from the tipple. The great cliff is composed of Carboniferous limestone. The smooth, darker slopes on the right of the picture are underlain by the Cretaceous coal measures. The plane of overthrust is beneath the talus slope.

crosses the flank of Goat mountain. There are a number of minor faults and "horses" encountered in the workings. The system of mining was first that of horizontal rooms, but lately the "diamond" system has been inaugurated.

There have been falls from the pillars and walls and some local squeezes, but there are no symptoms of a general squeeze.

The output of this mine as reported to the Alberta government, is as follows:—

	Tons.
1909.	19,304
1910.	66,540
	85,844

This is equivalent to 76,300 cubic yards of excavation.

To obtain an approximate idea of the percentage of extraction, the total length of workings of the shaft mine will be averaged at 3,400 feet; the depth will be considered 300 feet, which includes a 100 to 200 foot pillar under the surface; the thickness will be taken at eight feet. The volume obtained from these figures is 302,000 cubic yards. Dividing this into the yardage obtained from the tonnage reported, gives only 25 per cent extraction.

It must be noted, however, that this includes the large surface pillars, and that the pillars within the workings have not been extracted to any extent.

All the present workings of the shaft mine are north of that part of the coal seam which faces the specially dangerous area of the North peak (see Figure 11, and Map of Turtle Mountain and Vicinity, showing Danger Area).

Influence of Continued Mining in the Shaft Mine.

It does not seem probable that mining conducted north of the present southern limit of the shaft mine can seriously affect Turtle mountain. If the workings penetrate to considerable distance northwardly along the base of Bluff (Goat) mountain, that presents a new consideration. The position of the seam is not known more than one-fourth of a mile or so north of the smelter entry; but, from a study of the relation of structure to topography in this case, we conclude that there is no apparent danger of producing slides from Bluff (Goat) mountain.

Danger in Continued Mining in the Drift Mine

The present position of the mine entrance involves decided danger both to the mine and the miners. It was covered by the landslide of 1903, and the surface works were swept away. Many loose rocks on the slopes above threaten destruction. This entrance should be permanently closed and a new entrance should be made either at the extreme southern end of the mine, southeast of Turtle mountain, or else entrance should be obtained underground from the shaft mine at sufficient depth to be below possible buried water-courses. The levels should be driven in such a way (for example, with the safeguard of advance drill holes) as to receive the sanction of the representatives of the Alberta government.

This conclusion of your Commission, as to the present dangerous position of the drift mouth, is apart from considerations affecting future mining operations within the mine itself.

Influence of Continued Mining in the Drift Mine in Causing Slides.

The Director of the Dominion Survey pointed out in correspondence with the Alberta mining officials, as already noted, that there was an area of what he termed "extreme danger," and so marked it on a map of the mine submitted by these officials.

In this area he considered that any mining would be likely to precipitate a landslide. The northern limit of the "extreme danger zone" he placed at a point 1,400 feet north of the drift mouth in territory not yet entered by either mine. He placed the southern limit at a point not less than 3,500 feet south of the mouth, and thus coincident with the south edge of the great slide, but he made a note on the map that "south of this point mining not altogether safe"

Your Commission fully agrees with this conclusion as to the danger of causing slides from continued mining in this area, at least if done by the ordinary methods.

Hydraulic Packing.

The only method known to your Commission that would insure against appreciable subsidence is that of hydraulic packing with sand. This method is increasingly used in Germany, and with the greatest success in preventing the subsidence of the surface where

there are expensive buildings. The settlement after packing with ordinary sand is less than five per cent; with granulated slag settlement is inappreciable, as it probably would be with sharp, clean sand.

The use of loam and sandy clay, ashes or crushed shale is less successful, the settlement with such material being from 10 to 15 per cent.

It does not appear possible to employ sand filling under ordinary commercial conditions in the Turtle Mountain district. There are no large bodies of clean sand close at hand. The only available source from which material could be obtained in sufficient quantities would be the sandstone at the base of Bluff (Goat) mountain. This would have to be quarried, crushed, transported to, and flushed into the mine. The cost with the high labour costs that prevail in Alberta, plus repairs, renewals, and capital charges, would add not less than $1.25 per ton of coal extracted, even if done on a considerable scale. The cost of installing the necessary plant would also be great, so that the system appears commercially impossible under the competitive conditions of coal production in that district.

Dry Packing.

While the use of dry packing would probably lessen the amount of subsidence, the experience with the long-wall method of mining both in America and Europe, where dry packing is employed, indicates that a settlement of 40 to 60 per cent of the thickness of the seam must be expected. It takes several years to reach the full settlement, but any portion of such settlement might cause disastrous slides.

If coal pillars are left, this merely serves to delay the process, for under the great pressures due to depth, shales such as here constitute the hanging wall will "flow" and seal all openings.

C. Conclusions.

Danger from Mining.

Your Commission, therefore, concludes that under present commercial conditions it is not possible to mine within a certain area without incurring the danger of precipitating a great landslide. We place the north limit of this area at the present south limit of the

shaft-mine workings, and the south limit of the area at a point five thousand feet south of the mouth of the No. 1 mine. The latter limit has been placed so far south on account of the possibility that mining operations should cause a landslide from the South peak, which in turn might cause one from the North peak, thus endangering the town, and the tracks and equipment of the Canadian Pacific railway.

The only conditions under which mining should be carried on in the danger area above described are: (1) The townsite should be abandoned and the risk to the property of the Canadian Pacific railway assumed. (2) The present entrance to No. 1 (drift) mine should be abandoned and the mine should be operated by deep levels from the shaft mine or from an opening at the extreme southern end of the property in the vicinity of Hillcrest. (3) Unusually heavy pillars should be left throughout the danger area, particularly in the upper levels, and not more than 50 per cent of the coal shound be extracted. (4) The excavated areas should be packed.

Dangerous Natural Causes.

Taking into account: (*a*) the steepness of the eastern slope of Turtle mountain, (*b*) its peculiar structure, and especially the attitude of the joint planes (planes of scission), (*c*) the possibility of internal stresses, inherited from the period of original upheaval, (*d*) the effect of highly possible jars on the delicate mechanism of this particular mountain (jars of a moderate earthquake, like that of 1901 in this region, or slight settlement of the mine workings might precipitate a slide of the first order), (*e*) the strong similarity of the conditions now to those immediately preceding the slide of 1903, (*f*) the special danger to the stability of the North Peak block induced by the 1903 slide, (*g*) the evidence of the recent development of fissures in the North peak, and (*h*) the difficulty of forecasting the exact course of the threatened slide or slides—your Commission is agreed on the following conclusions, namely:

Irrespective of mining operations and because of existing conditions only, there is danger of a disastrous landslide from Turtle mountain. We are agreed that danger exists from what has hitherto been called, in this report, the North Peak block. The size and position of this block is indicated on the "Map of Turtle Mountain and Vicinity showing Danger Area." The limits of the block have

Bluff (Goat) mountain looking north northeast from northern spur of Turtle mountain, showing the relatively low dips of the limestone at the eastern escarpment.

been roughly marked thereon by paying due attention to the analogy of the block which fell in 1903 (Figure 29, showing the *splay* of this slide), and to the attitude of the joint-planes in the mountain. In our opinion, the lower limit of this threatening block occurs at the outcrop of the zone of contorted beds in the limestone member (see Plate XV).

We are further agreed that the area likely to be overrun by the debris of this slide is shown with practical accuracy (as the "area endangered") on the "Map of Turtle Mountain and Vicinity showing Danger Area." In tracing the limits of this danger, your Commission has used the analogy of the 1903 slide and has allowed a fair "margin of safety," necessitated by accidental factors that might influence the course of the threatened slide.

Excepting the North Peak block, the South Peak block, and the fissured area between them, we believe that the danger of heavy slides into the Frank valley cannot be classed as imminent. Yet it should be carefully noted that, in the opinion of your Commission, both the estimate of the size of the threatening block and the area likely to be devastated have been conservatively estimated and so indicated on the "Map of Turtle Mountain and Vicinity showing Danger Area." It is impossible to deny the existence of danger to the part of the valley at and north of the mine shaft. We believe, however, that the new Rocky Mountain Sanatorium lies outside the zone of practical danger.

As already noted, we believe that there is danger of heavy slides from the South peak and from the fissured region just to the north. We have not mapped their probable course, since this would lie practically altogether in the already mined and now uninhabited area overrun by the 1903 slide.

On account of the dips of bedding and joints in the limestone of Bluff (Goat mountain, as locally named), we are of opinion that there is no practical danger of a first-order slide from that mountain in its present condition (See Plate XIX).

Abandonment of the Town-site.

The present shaft and mine buildings surrounding it, also the row of houses to the northwest of it, appear to be reasonably safe from the effect of a slide from Turtle mountain. Practically all the rest of the town-site should be abandoned. In the opinion of

your Commission this should be done whether the mine is operated in the danger zone or not, on account of the unstable condition, from natural causes, of the North and South peaks.

Whatever the report of this or other Commission, the town can never be an important one on its present site, since there will always remain the dread of another calamitous slide like that of 1903. In spite of undoubted individual hardship, caused by abandonment of the present site, the town, on a new and safe site, might prosper as never before.

(Signed) **Reginald A. Daly,**
W. G. Miller,
George S. Rice.

CANADA

DEPARTMENT OF MINES

GEOLOGICAL SURVEY BRANCH

HON. W. B. NANTEL, MINISTER; A. P. LOW, DEPUTY MINISTER;
R. W. BROCK, DIRECTOR.

SELECTED LIST OF REPORTS AND MAPS

(SINCE 1885)

OF SPECIAL ECONOMIC INTEREST

PUBLISHED BY

THE GEOLOGICAL SURVEY.

Report of the Mines Section:—

No. 245.	Report of Mines Section,	1886.	No. 662.	Report of Mines Section,	1897.
272	" "	1887.	698	" "	1898.
*300	" "	1888.	718	" "	1899.
301	" "	1889.	744	" "	1900.
334	" "	1890.	800	" "	1901.
335	" "	1891.	835	" "	1902.
360	" "	1892.	893	" "	1903.
572	" "	1893-4.	*928	" "	1904.
602	" "	1895.	971	" "	1905.
62.	" "	1896.			

Mineral Production of Canada:—

No. *414.	Year 1886.	No. *422.	Year 1893.	No. 719.	Year 1900.
*415	" 1887.	*555	" 1894	719a	" 1901.
*416	" 1888.	*577	" 1895	813	" 1902.
*417	" 1889.	*612	" 1896.	861	" 1903.
*418	" 1890.	*623	" 1886–96	896	" 1904.
*419	" 1891.	*640	" 1897.	924	" 1905.
*420	" 1886–91	*671	" 1898.	981	" 1906.
*421	" 1892.	*686	" 1899.		

Mineral Resources Bulletin:—

No. *818.	Platinum.	No. 860.	Zinc.	No. 881.	Phosphate.
851.	Coal.	869.	Mica.	882.	Copper.
*854.	Asbestos.	872.	Molybdenum and Tungsten.	913.	Mineral Pigments.
857.	Infusorial Earth.	*877.	Graphite.	953.	Barytes.
858.	Manganese.	880.	Peat.	984.	Mineral Pigments (French).
859	Salt.				

Report of the Section of Chemistry and Mineralogy:—

No. *102.	Year 1874–5.	No. *169.	Year 1882-3-4.	No. 580.	Year 1894.
*110	" 1875–6.	222.	" 1885.	616	" 1895.
*119	" 1876–7.	246	" 1886.	651	" 1896.
*126	" 1877–8.	273	" 1887–8.	695	" 1898.
*138	" 1878–9.	299	" 1888–8.	724	" 1899.
*148	" 1879–80.	333	" 1890–1.	821	" 1900.
*156	" 1880–1–2.	359	" 1892–3.	*958	" 1906.

*Publications marked thus are out of print.

REPORTS.

GENERAL.

745. Altitudes of Canada, by J. White. 1899.
*972. Descriptive Catalogue of Minerals and Rocks, by R. A. A. Johnston and G. A. Young.
1073. Catalogue of Publications: Reports and Maps (1843-1909).
1085. Descriptive Sketch of the Geology and Economic Minerals of Canada, by G. A. Young, and Introductory by R. W. Brock. Maps No. 1084; No. 1042 (second edition), scale 100 m. = 1 in.
1086. French translation of Descriptive Sketch of the Geology and Economic Minerals of Canada, by G. A. Young, and Introductory by R. W. Brock. Maps No. 1084; No. 1042 (second edition), scale 100 m. = 1 in.
1107. Part II. Geological position and character of the oil-shale deposits of Canada, by R. W. Ells.
1146. Notes on Canada, by R. W. Brock.

YUKON.

*260. Yukon district, by G. M. Dawson. 1887. Maps No. 274, scale 60 m. = 1 in.; Nos. 275 and 277, scale 8 m = 1 in.
*295. Yukon and Mackenzie basins, by R. G. McConnell. 1889. Map No. 304, scale 48 m. = 1 in.
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884. Klondike gold fields, by R. G. McConnell. 1901. Map No. 772, scale 2 m. = 1 in.
*909. Windy Arm, Tagish lake, by R. G. McConnell. 1906. Map No. 916, scale 2 m. = 1 in.
943. Upper Stewart river, by J. Keele. Map No. 938, scale 8 m. = 1 in. } Bound together.
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982. Conrad and Whitehorse mining districts, by D. D. Cairnes. 1901. Map No. 990, scale 2 m. = 1 in.
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1050. Whitehorse Copper Belt, by R. G. McConnell. Maps Nos. 1,026, 1,041, 1,044-1,049.
1097. Reconnaissance across the Mackenzie mountains on the Pelly, Ross, and Gravel rivers, Yukon, and North West Territories, by Joseph Keele. Map No. 1099, scale 8 m. = 1 in.
1011. Memoir No. 5 (Preliminary): on the Lewes and Nordenskiöld Rivers coal field, Yukon, by D. D. Cairnes. Maps Nos. 1103 and 1104, scale 2 m. = 1 in.

BRITISH COLUMBIA.

212. The Rocky mountains (between latitudes 49° and 51° 30′), by G. M. Dawson. 1885. Map No. 223, scale 6 m. = 1 in. Map No. 224, scale 1½ m. = 1 in.
*235. Vancouver island, by G. M. Dawson. 1886. Map No. 247, scale 8 m. = 1 in.
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263. Cariboo mining district, by A. Bowman. 1887. Maps Nos. 278-281.
*271. Mineral wealth, by G. M. Dawson.
*294. West Kootenay district, by G. M. Dawson. 1888-9. Map No. 303, scale 8 m. = 1 in.
*573. Kamloops district, by G. M. Dawson. 1894. Maps Nos. 556 and 557, scale 4 m. = 1 in.
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743. Atlin Lake mining division, by J. C. Gwillim. 1899. Map No. 742, scale 4 m. = 1 in.
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1093. Geology, and Ore Deposits of Hedley Mining district, British Columbia, by Charles Camsell. Maps Nos. 1095 and 1096, scale 1,000 ft. = 1 in.; No. 1105, scale 600 ft. = 1 in.; No. 1106, scale 800 ft. = 1 in.; No. 1125, scale 1,000 ft. = 1 in.

ALBERTA.

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703. Yellowhead Pass route, by J. McEvoy. 1898. Map No. 676, scale 8 m. = 1 in.
*949. Cascade coal-fields, by D. B. Dowling. Maps (8 sheets) Nos. 929-936, scale 1 m. = 1 in.
968. Moose Mountain district, by D. D. Cairnes. Maps No. 963, scale 2 m. = 1 in.; No. 966, scale 1 m. = 1 in.
1035. Coal-fields of Manitoba, Saskatchewan, Alberta, and Eastern British Columbia, by D. B. Dowling. Map No. 1010, scale 35 m. = 1 in.
1035a. French translation of coal-fields of Manitoba, Saskatchewan, Alberta, and Eastern British Columbia, by D. B. Dowling. Map No. 1010, scale 35 m. = 1 in.
1115. Memoir No. 8-E: Edmonton coal-field, by D. B. Dowling. Maps Nos. 1117-5A and 1118-6A, scale 2640 ft. = 1 in.
1130. Memoir No. 9-E: Bighorn coal basin, Alta., by G. S. Malloch. Map No. 1132, scale 2 m. = 1 in.
1211. Memoir No. 27. Report of Commission appointed to investigate Turtle mountain, Frank, Alta., 1911.

SASKATCHEWAN.

213. Cypress hills and Wood mountain, by R. G. McConnell. 1885. Maps Nos. 225 and 226, scale 8 m. = 1 in.
601. Country between Athabaska lake and Churchill river, by J. B. Tyrrell and D. B. Dowling. 1895. Map No. 957, scale 25 m. = 1 in.
868. Souris River coal-field, by D. B. Dowling. 1902.
1035. Coal-fields of Manitoba, Saskatchewan, Alberta, and Eastern British Columbia, by D. B. Dowling. Map No. 1010, scale 35 m. = 1 in.

MANITOBA.

264. Duck and Riding mountains, by J. B. Tyrrell. 1887-8. Map No. 282 scale 8 m. = 1 in.
296. Glacial Lake Agassiz, by W. Upham. 1889. Maps Nos. 314, 315, 316.
325. Northwestern portion, by J. B. Tyrrell. 1890-1. Maps Nos. 339 and 350, scale 8 m. = 1 in.
704. Lake Winnipeg (west shore), by D. B. Dowling. 1898. Map No. 664, scale 8 m. = 1 in.
705. Lake Winnipeg (east shore), by J. B. Tyrrell. 1898. Map No. 664, scale 8 m. = 1 in.
Bound together.
1035. Coal-fields of Manitoba, Saskatchewan, Alberta, and Eastern British Columbia, by D. B. Dowling. Map No. 1010, scale 35 m. = 1 in.

NORTH WEST TERRITORIES.

217. Hudson bay and strait, by R. Bell. 1885. Map No. 229, scale 4 m. = 1 in

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238. Hudson bay, south of, by A. P. Low. 1886.
Attawapiskat and Albany rivers, by R. Bell. 1886.
244. Northern portion of the Dominion, by G. M. Dawson. 1886. Map No. 255, scale 200 m. = 1 in.
267. James bay and country east of Hudson bay, by A. P. Low.
578. Red lake and part of Berens river, by D. B. Dowling. 1894. Map No. 576, scale 8 m. = 1 in.
*584. Labrador peninsula, by A. P. Low. 1895. Maps Nos. 585-588, scale 25 m. = 1 in.
618. Dubawnt, Kazan, and Ferguson rivers, by J. B. Tyrrell. 1896. Map No. 603, scale 25 m. = 1 in.
657. Northern portion of the Labrador peninsula, by A. P. Low.
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713. North Shore Hudson strait and Ungava bay, by R. Bell. Map No. 699, scale 25 m. = 1 in.
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725. Great Bear lake to Great Slave lake, by J. M. Bell. 1900.
778. East coast Hudson bay, by A. P. Low. 1900. Maps Nos. 779, 780, 781, scale 8 m. = 1 in.
786–787. Grass River region, by J. B. Tyrrell and D. B. Dowling. 1900.
815. Ekwan river and Sutton lakes, by D. B. Dowling. 1901. Map No. 751, scale 50 m. = 1 in.
819. Nastapoka islands, Hudson bay, by A. P. Low. 1900.
905. The Cruise of the *Neptune*, by A. P. Low. 1905.
1006. Report of a Traverse through the Southern Part of the North West Territories, from Lac Seul to Cat lake, 1902, by A. W. G. Wilson.
1080. Report on a Part of the North West Territories, drained by the Winisk and Upper Attawapiskat rivers, by W. McInnes. Map No. 1089, scale 8 m. = 1 in.
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1069. French translation report on an exploration of the East coast of Hudson bay, from Cape Wolstenholme to the south end of James bay, by A. P. Low. Maps Nos. 779, 780, 781, scale 8 m. = 1 in.; No. 785, scale 50 m. = 1 in.
1097. Reconnaissance across the Mackenzie mountains on the Pelly, Ross, and Gravel rivers, Yukon, and North West Territories, by Joseph Keele. Map No. 1099, scale 8 m. = 1 in.

ONTARIO.

215. Lake of the Woods region by A. C. Lawson. 1885. Map No. 227, scale 2 m. = 1 in.
*265. Rainy Lake region, by A. C. Lawson. 1887. Map No. 283, scale 4 m. = 1 in.
266. Lake Superior, mines and mining, by E. D. Ingall. 1888. Maps No. 285, scale 4 m. = 1 in.; No. 286, scale 20 ch. = 1 in.
326. Sudbury mining district, by R. Bell. 1890-1. Map No. 343, scale 4 m. = 1 in.
327. Hunter island, by W. H. C. Smith. 1890-1. Map No. 342, scale 4 m. = 1 in.
332. Natural Gas and Petroleum, by H. P. H. Brumell. 1890-1. Maps Nos. 344-349.
357. Victoria, Peterborough, and Hastings counties, by F. D. Adams. 1892-3.
627. On the French River sheet, by R. Bell. 1896. Map No. 570, scale 4 m. = 1 in.
678. Seine river and Lake Shebandowan map-sheets, by W. McInnes. 1897. Maps Nos. 589 and 560, scale 4 m. = 1 in.
723. Iron deposits along the Kingston and Pembroke railway, by E. D. Ingall. 1900. Map No. 626, scale 2 m. = 1 in.; and plans of 13 mines.
*739. Carleton, Russell, and Prescott counties, by R. W. Ells. 1899. (*See* No. 739, Quebec.)
741. Ottawa and vicinity, by R. W. Ells. 1900.
790. Perth sheet, by R. W. Ells. 1900. Map No. 789, scale 4 m. = 1 in.
961. Sudbury Nickel and Copper deposits, by A. E. Barlow. (Reprint.) Maps Nos. 775, 820, scale 1 m. = 1 in.; Nos. 824, 825, 864, scale 400 ft. = 1 in.

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962. Nipissing and Timiskaming map-sheets, by A. E. Barlow. (Reprint). Maps Nos. 599, 606, scale 4 m. = 1 in.; No. 944, scale 1 m. = 1 in.
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970. Report on Niagara Falls, by J. W. Spencer. Maps Nos. 926, 967.
977. Report on Pembroke sheet, by R. W. Ells. Map No. 660, scale 4 m. = 1 in.
980. Geological reconnaissance of a portion of Algoma and Thunder Bay district, Ont., by W. J. Wilson. Map No. 964, scale 8 m. = 1 in. } Bound together.
1081. On the region lying north of Lake Superior, between the Pic and Nipigon rivers, Ont., by W. H. Collins. Map No. 964, scale 8 m. = 1 in. } Bound together.
992. Report on Northwestern Ontario, traversed by National Transcontinental railway, between Lake Nipigon and Sturgeon lake, by W. H. Collins. Map No. 993, scale 4 m. = 1 in.
998. Report on Pembroke sheet, by R. W. Ells. (French.) Map No. 660, scale 4 m. = 1 in.
999. French translation Gowganda Mining Division, by W. H. Collins. Map No. 1076, scale 1 m. = 1 in.
1038. French translation report on the Transcontinental Railway location between Lake Nipigon and Sturgeon lake, by W. H. Collins. Map No. 993, scale 4 m. = 1 in.
1059. Geological reconnaissance of the region traversed by the National Transcontinental railway between Lake Nipigon and Clay lake, Ont., by W. H. Collins. Map No. 993, scale 4 m. = 1 in.
1075. Gowganda Mining Division, by W. H. Collins. Map No. 1076, scale 1 m. = 1 in.
1082. Memoir No. 6: Geology of the Haliburton and Bancroft areas, Ont., by Frank D. Adams and Alfred E. Barlow. Maps No. 708, scale 4 m. = 1 in.; No. 770, scale 2 m. = 1 in.
1091. Memoir No. 1: On the Geology of the Nipigon basin, Ont., by A. W. G. Wilson. Map No. 1090, scale 4 m. = 1 in.
1114. French translation: Geological reconnaissance of a portion of Algoma and Thunder Bay district, Ont., by W. J. Wilson. Map No. 964, scale 8 m. = 1 in. } Bound together.
1119. French translation: On the region lying north of Lake Superior, between the Pic and Nipigon rivers, Ont., by W. H. Collins. Map No. 964, scale 8 m. = 1 in. } Bound together.

QUEBEC.

216. Mistassini expedition, by A. P. Low. 1884-5. Map No. 228, scale 8 m. = 1 in.
240. Compton, Stanstead, Beauce, Richmond, and Wolfe counties, by R. W. Ells. 1886. Map No. 251 (Sherbrooke sheet), scale 4 m. = 1 in.
268. Megantic, Beauce, Dorchester, Levis, Bellechasse, and Montmagny counties, by R. W. Ells. 1887-8. Map No. 287, scale 40 ch. = 1 in.
297. Mineral resources, by R. W. Ells. 1889.
328. Portneuf, Quebec, and Montmagny counties, by A. P. Low. 1890-1.
579. Eastern Townships, Montreal sheet, by R. W. Ells and F. D. Adams. 1894. Map No. 571, scale 4 m. = 1 in.
591. Laurentian area north of the Island of Montreal, by F. D. Adams. 1895. Map No. 590, scale 4 m. = 1 in.
670. Auriferous deposits, southeastern portion, by R. Chalmers. 1895. Map No. 667, scale 8 m. = 1 in.
707. Eastern Townships, Three Rivers sheet, by R. W. Ells. 1898.
*739. Argenteuil, Ottawa, and Pontiac counties, by R. W. Ells. 1899. (*See* No. 739, Ontario).
788. Nottaway basin, by R. Bell. 1900. *Map No. 702, scale 10 m. = 1 in.
863. Wells on Island of Montreal, by F. D. Adams. 1901. Maps Nos. 874, 875, 876.
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974. Report on Copper-bearing rocks of Eastern Townships, by J. A. Dresser. Map No. 976, scale 8 m. = 1 in.
975. Report on Copper-bearing rocks of Eastern Townships, by J. A. Dresser. (French).
998. Report on the Pembroke sheet, by R. W. Ells. (French).

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1028. Report on a Recent Discovery of Gold near Lake Megantic, Que., by J. A. Dresser. Map No. 1029, scale 2 m. = 1 in.
1032. Report on a Recent Discovery of Gold near Lake Megantic, Que., by J. A. Dresser. (French). Map No. 1029, scale 2 m. = 1 in.
1052. French translation report on Artesian wells in the Island of Montreal, by Frank D. Adams and O. E. LeRoy. Maps No. 874, scale 4 m. = 1 in.; No. 375, scale 3,000 ft. = 1 in.; No. 876.
1064. Geology of an Area adjoining the East Side of Lake Timiskaming, Que., by Morley E. Wilson. Map No. 1066, scale 1 m. = 1 in.
1110. Memoir No. 4: Geological Reconnaissance along the line of the National Transcontinental railway in Western Quebec, by W. J. Wilson. Map No. 1112, scale 4 m. = 1 in.
1144. Reprint of Summary Report on the Serpentine Belt of Southern Quebec, by J. A. Dresser.

NEW BRUNSWICK.

218. Western New Brunswick and Eastern Nova Scotia, by R. W. Ells. 1885. Map No. 230, scale 4 m. = 1 in.
219. Carleton and Victoria counties, by L. W. Bailey. 1885. Map No. 231, scale 4 m. = 1 in.
242. Victoria, Restigouche, and Northumberland counties, N.B., by L. W. Bailey and W. McInnes. 1886. Map No. 254, scale 4 m. = 1 in.
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661. Mineral resources, by L. W. Bailey. 1897. Map No. 675, scale 10 m. = 1 in. New Brunswick geology, by R. W. Ells. 1887.
799. Carboniferous system, by L. W. Bailey. 1900. } Bound together.
803. Coal prospects in, by H. S. Poole. 1900. }
983. Mineral resources, by R. W. Ells. Map No. 969, scale 16 m. = 1 in.
1034. Mineral resources, by R. W. Ells. (French). Map No. 969, scale 16 m. = 1 in.
1113. Memoir No. 16-E: The Clay and Shale deposits of Nova Scotia and portions of New Brunswick, by H. Ries and J. Keele. Map No. 1153, scale 12 m. = 1 in.

NOVA SCOTIA.

243. Guysborough, Antigonish, Pictou, Colchester, and Halifax counties, by Hugh Fletcher and E. R. Faribault. 1886.
331. Pictou and Colchester counties, by H. Fletcher. 1890–1.
358. Southwestern Nova Scotia (preliminary), by L. W. Bailey. 1892–3. Map No. 362, scale 8 m. = 1 in.
628. Southwestern Nova Scotia, by L. W. Bailey. 1896. Map No. 641, scale 8 m. = 1 in.
685. Sydney coal-field, by H. Fletcher. Maps Nos. 652, 653, 654, scale 1 m. = 1 in.
797. Cambrian rocks of Cape Breton, by G. F. Matthew. 1900
871. Pictou coal-field, by H. S. Poole. 1902. Map No. 833, scale 25 ch. = 1 in.
1113. Memoir No. 16-E: The Clay and Shale deposits of Nova Scotia and portions of New Brunswick, by H. Ries and J. Keele. Map No. 1153, scale 12 m. = 1 in.

MAPS.

1042. Dominion of Canada. Minerals. Scale 100 m. = 1 in.

YUKON.

*805. Explorations on Macmillan, Upper Pelly, and Stewart rivers, scale 8 m. = 1 in.
891. Portion of Duncan Creek Mining district, scale 6 m. = 1 in.
894. Sketch Map Kluane Mining district, scale 6 m. = 1 in.

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*916. Windy Arm Mining district, Sketch Geological Map, scale 2 m. = 1 in.
990. Conrad and Whitehorse Mining districts, scale 2 m. = 1 in.
991. Tantalus and Five Fingers coal mines, scale 1 m. = 1 in.
1011. Bonanza and Hunker creeks. Auriferous gravels. Scale 40 chains = 1 in
1033. Lower Lake Laberge and vicinity, scale 1 m. = 1 in.
1041. Whitehorse Copper belt, scale 1 m. = 1 in.
1026, 1044–1049. Whitehorse Copper belt. Details.
1099. Pelly, Ross, and Gravel rivers, Yukon and North West Territories. Scale 8 m. = 1 in.
1103. Tantalus Coal area. Scale 2 m. = 1 in.
1104. Braeburn-Kynocks Coal area. Scale 2 m. = 1 in.

BRITISH COLUMBIA.

278. Cariboo Mining district, scale 2 m. = 1 in.
604. Shuswap Geological sheet, scale 4 m. = 1 in.
*771. Preliminary Edition, East Kootenay, scale 4 m. = 1 in.
767. Geological Map of Crowsnest coal-fields, scale 2 m. = 1 in.
*791. West Kootenay Minerals and Striæ, scale 4 m. = 1 in.
*792. West Kootenay Geological sheet, scale 4 m. = 1 in.
828. Boundary Creek Mining district, scale 1 m. = 1 in.
890. Nicola coal basin, scale 1 m. = 1 in.
941. Preliminary Geological Map of Rossland and vicinity, scale 1,600 ft. = 1
987. Princeton coal basin and Copper Mountain Mining camp, scale 40 ch. = 1 in
989. Telkwa river and vicinity, scale 2 m. = 1 in.
997. Nana[illegible] and New Westminster Mining division, scale 4 m. = 1 in.
1001. Speci.. Map of Rossland. Topographical sheet. Scale 400 ft. = 1 in.
1002. Special Map of Rossland. Geological sheet. Scale 400 ft. = 1 in.
1003. Rossland Mining camp. Topographical sheet. Scale 1,200 ft. = 1 in.
1004. Rossland Mining camp. Geological sheet. Scale 1,200 ft. = 1 in.
1068. Sheep Creek Mining camp. Geological sheet. Scale 1 m. = 1 in.
1074. Sheep Creek Mining camp. Topographical sheet. Scale 1 m. = 1 in.
1095. 1A.—Hedley Mining district. Topographical sheet. Scale 1,000 ft. = 1 in.
1096. 2A.—Hedley Mining district. Geological sheet. Scale 1,000 ft. = 1 in.
1105. 4A.—Golden Zone Mining camp. Scale 600 ft. = 1 in.
1106. 3A.—Mineral Claims on Henry creek. Scale 800 ft. = 1 in.
1125. Hedley Mining district: Structure Sections. Scale 1,000 ft. = 1 in
Deadwood Mining camp. Scale 400 ft. = 1 in. (Advance sheet.)
1164. 28A.—Portland Canal Mining district, scale 2 m. = 1 in.
Beaverdell sheet, Yale district, scale 1 m. = 1 in. (Advance sheet.)
Tulameen sheet, scale 1 m. = 1 in. (Advance sheet.)

ALBERTA.

594-596. Peace and Athabaska rivers, scale 10 m. = 1 in.
*808. Blairmore-Frank coal-fields, scale 180 ch. = 1 in.
892. Costigan coal basin, scale 40 ch. = 1 in.
929-936. Cascade coal basin. Scale 1 m. = 1 in.
963-966. Moose Mountain region. Coal Areas. Scale 2 m. = 1 in.
1010. Alberta, Saskatchewan, and Manitoba. Coal Areas. Scale 35 m. = 1 in
1117. 5A.—Edmonton. (Topography). Scale ½ m. = 1 in.
1118. 6A.—Edmonton. (Clover Bar Coal Seam). Scale ½ m. = 1 in.
1132. 7A.—Bighorn coal-field. Scale 2 m. = 1 in.
Portion of Jasper Park, scale 1 m. = 1 in. (Advance sheet.)

SASKATCHEWAN.

1010. Alberta, Saskatchewan, and Manitoba. Coal Areas. Scale 35 m. = 1 in.

MANITOBA.

804. Part of Turtle mountain showing coal areas. Scale 1½ m. = 1 in.
1010. Alberta, Saskatchewan, and Manitoba. Coal Areas. Scale 35 m. = 1 in

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NORTH WEST TERRITORIES.

1089. Explored routes on Albany, Severn, and Winisk rivers. Scale 8 m. = 1 in.
1099. Pelly, Ross, and Gravel rivers, Yukon and North West Territories. Scale 8 m. = 1 in.

ONTARIO.

227. Lake of the Woods sheet, scale 2 m. = 1 in.
*283. Rainy Lake sheet, scale 4 m. = 1 in.
*342. Hunter Island sheet, scale 4 m. = 1 in.
343. Sudbury sheet, scale 4 m. = 1 in.
*373. Rainy River sheet, scale 2 m. = 1 in.
560. Seine River sheet, scale 4 m. = 1 in.
570. French River sheet, scale 4 m. = 1 in.
*589. Lake Shebandowan sheet, scale 4 m. = 1 in.
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605. Manitoulin Island sheet, scale 4 m. = 1 in.
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*750. Grenville sheet, scale 4 m. = 1 in.
770. Bancroft sheet, scale 2 m. = 1 in.
775. Sudbury district, Victoria mines, scale 1 m. = 1 in.
*789. Perth sheet, scale 4 m. = 1 in.
820. Sudbury district, Sudbury, scale 1 m. = 1 in.
824-825. Sudbury district, Copper Cliff mines, scale 400 ft. = 1 in.
852. Northeast Arm of Vermilion Iron ranges, Timagami, scale 40 ch. = 1 in.
864. Sudbury district, Elsie and Murray mines, scale 400 ft. = 1 in.
903. Ottawa and Cornwall sheet, scale 4 m. = 1 in.
944. Preliminary Map of Timagami and Rabbit lakes, scale 1 m. = 1 in.
964. Geological Map of parts of Algoma and Thunder bay, scale 8 m. = 1 in.
1023. Corundum Bearing Rocks, Central Ontario. Scale 17½ m. = 1 in.
1076. Gowganda Mining Division, scale 1 m. = 1 in.
1090. Lake Nipigon, Thunder Bay district, scale 4 m. = 1 in.

QUEBEC.

*251. Sherbrooke sheet, Eastern Townships Map, scale 4 m. = 1 in.
287. Thetford and Coleraine Asbestos district, scale 40 ch. = 1 in.
375. Quebec sheet, Eastern Townships Map, scale 4 m. = 1 in.
*571. Montreal sheet, Eastern Townships sheet, scale 4 m. = 1 in.
*665. Three Rivers sheet, Eastern Townships Map, scale 4 m. = 1 in.
667. Gold Areas in southeastern part, scale 8 m. = 1 in.
*668. Graphite district in Labelle county, scale 40 ch. = 1 in.
918. Chibougamau region, scale 4 m. = 1 in.
976. The Older Copper-bearing Rocks of the Eastern Townships, scale 8 m. = 1 in.
1007. Lake Timiskaming region, scale 2 m. = 1 in.
1029. Lake Megantic and vicinity, scale 2 m. = 1 in.
1066. Lake Timiskaming region. Scale 1 m. = 1 in.
1112. 12A—Vicinity of the National Transcontinental railway, Abitibi district, scale 4 m. = 1 in.
1154. 23A—Thetford-Black Lake Mining district, scale 1 m. = 1 in.
Larder lake and Opasatika lake, scale 2 m. = 1 in. (Advance sheet.)
Danville Mining district, scale 1 m. = 1 in. (Advance sheet.)

NEW BRUNSWICK.

*675. Map of Principal Mineral Occurrences. Scale 10 m. = 1 in.
969. Map of Principal Mineral Localities. Scale 16 m. = 1 in.
1155. 24A—Millstream Iron deposits, N.B., scale 400 ft. = 1 in.
1156. 25A—Nipisiguit Iron deposits, N.B., scale 400 ft. = 1 in.

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NOVA SCOTIA.

*812. Preliminary Map of Springhill coal-field, scale 50 ch. = 1 in.
833. Pictou coal-field, scale 25 ch. = 1 in.
897. Preliminary Geological Plan of Nictaux and Torbrook Iron district, scale 25 ch. = 1 in.
927. General Map of Province showing gold districts, scale 12 m. = 1 in.
937. Leipsigate Gold district, scale 500 ft. = 1 in.
945. Harrigan Gold district, scale 400 ft. = 1 in.
995. Malaga Gold district, scale 250 ft. = 1 in.
1012. Brookfield Gold district, scale 250 ft. = 1 in.
1019. Halifax Geological sheet. No. 68. Scale 1 m. = 1 in.
1025. Waverley Geological sheet. No. 67. Scale 1 m. = 1 in.
1036. St. Margaret Bay Geological sheet. No. 71. Scale 1 m. = 1 in.
1037. Windsor Geological sheet. No. 73. Scale 1 m. = 1 in.
1043. Aspotogan Geological sheet No. 70. Scale 1 m. = 1 in.
1153. 22A—Nova Scotia, scale 12 m. = 1 in.

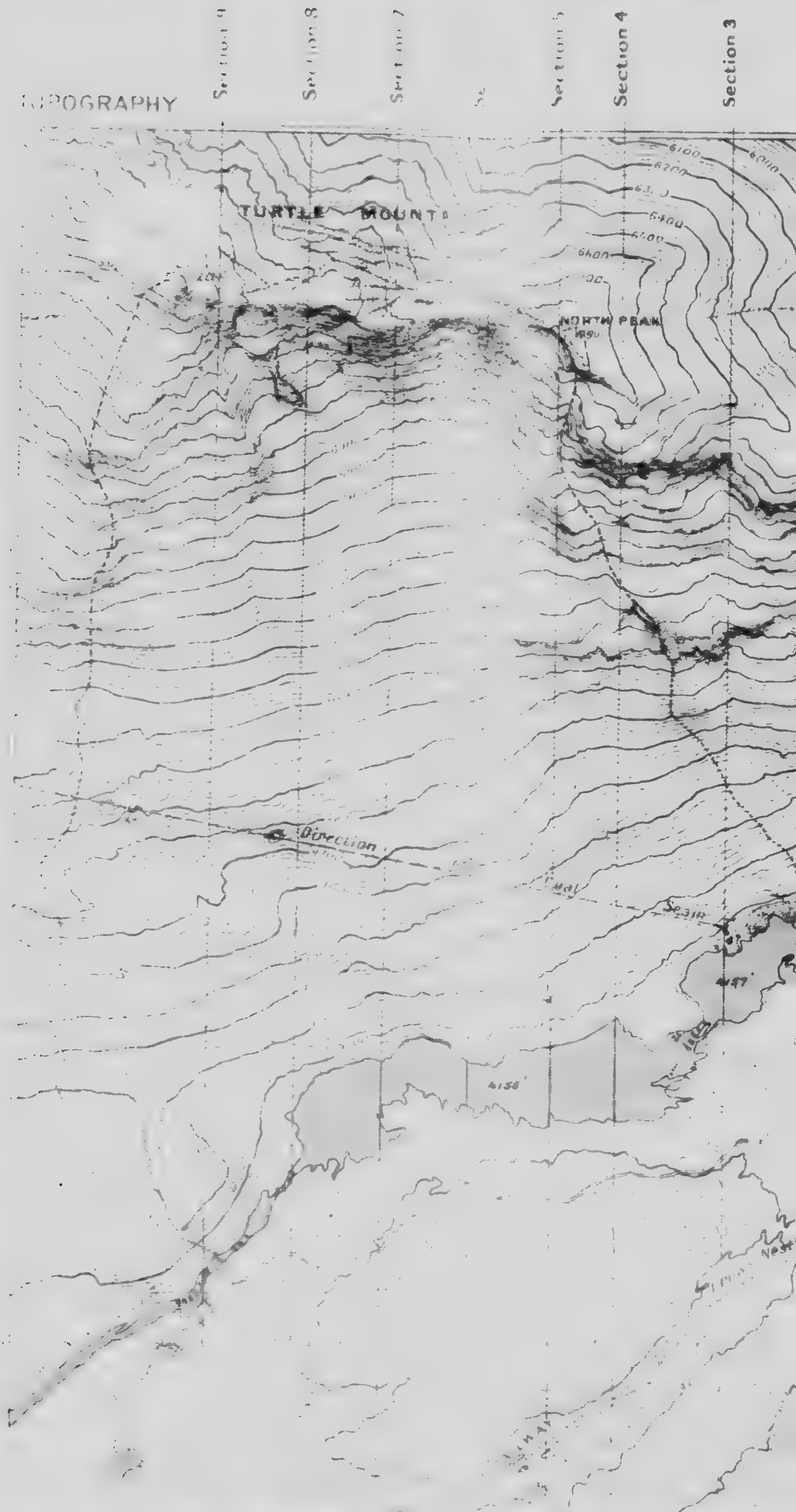
NOTE.—Individual Maps or Reports will be furnished free to *bona fide* Canadian applicants.

Reports and Maps may be ordered by the numbers prefixed to titles.

Applications should be addressed to The Director, Geological Survey. Department of Mines, Ottawa.

*Publications marked thus are out of print.

ŊPOGRAPHY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Section 4
Section 3
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NORTH PEAK
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Seam
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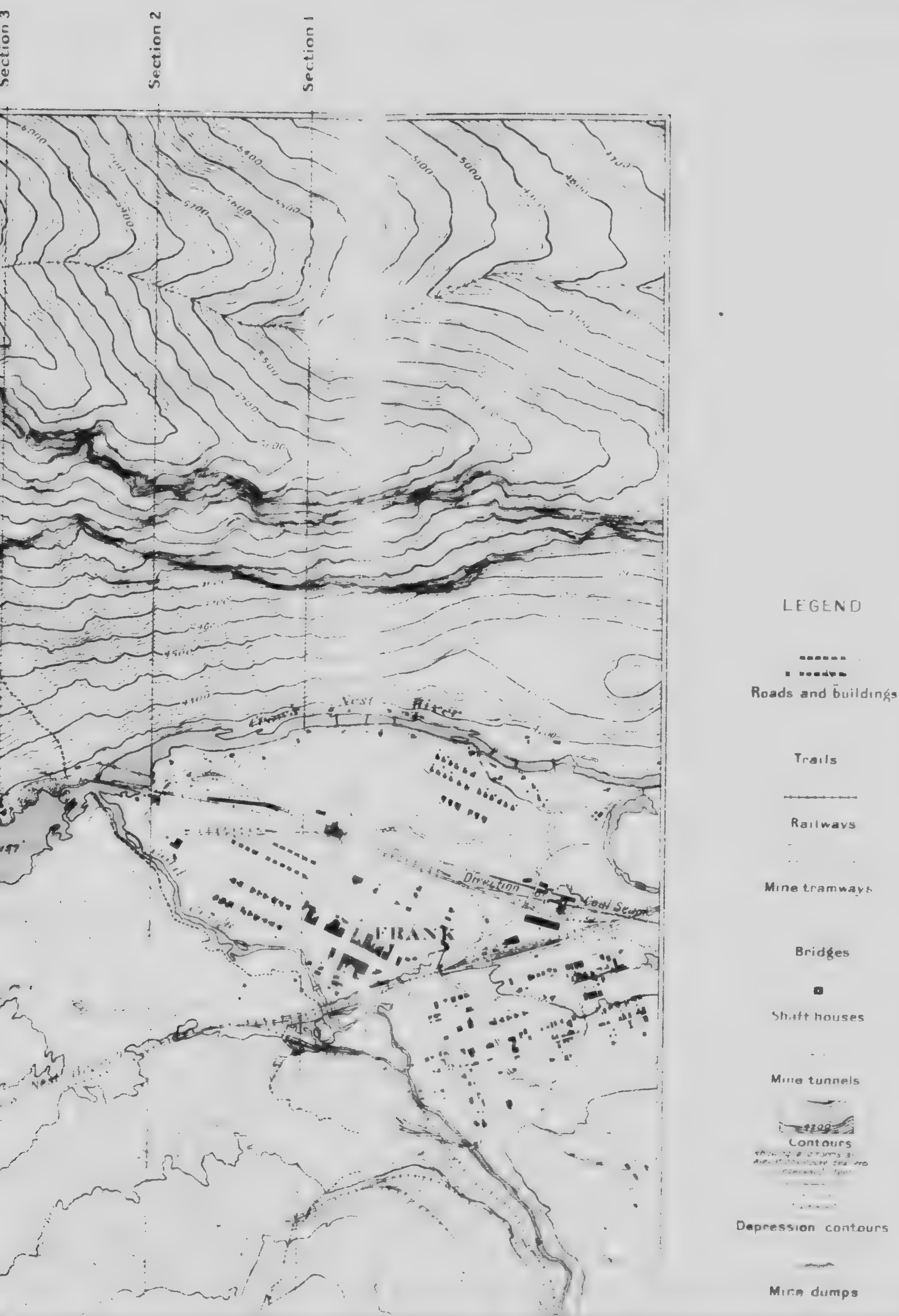
Section 3
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5000
4800
4500
Crow's Nest River
Direction of Coal Seam
FRANK
LEGEND
Roads and buildings
Trails
Railways
Mine tramways
Bridges
Shaft houses
Mine tunnels
4200
Contours
Depression contours
Mine dumps

TURTLE MOUNTAIN A

ALBERTA

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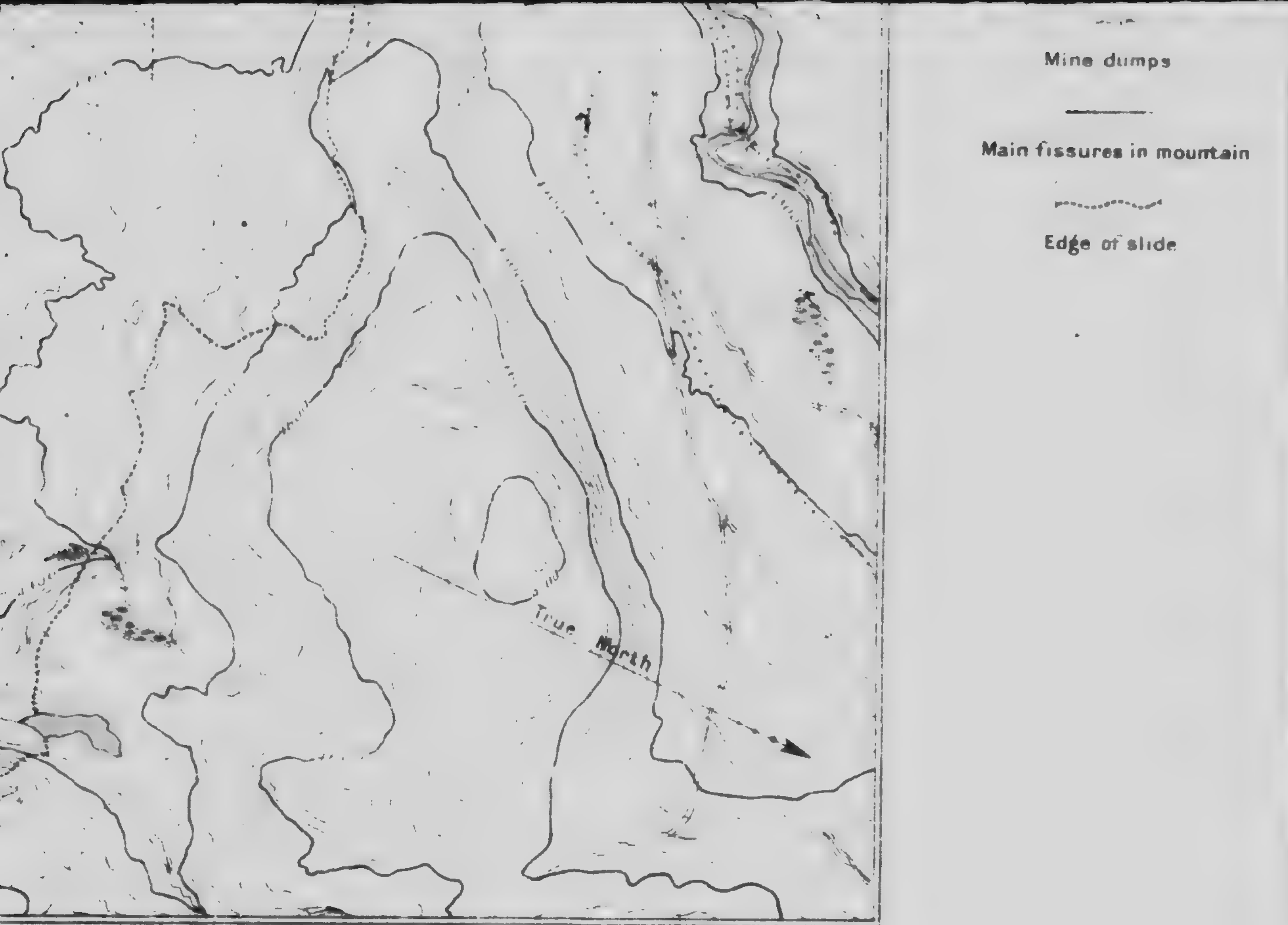

Topography by Geological Survey
W.H. Boyd (in charge)

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of Turtle Mountain, 1911

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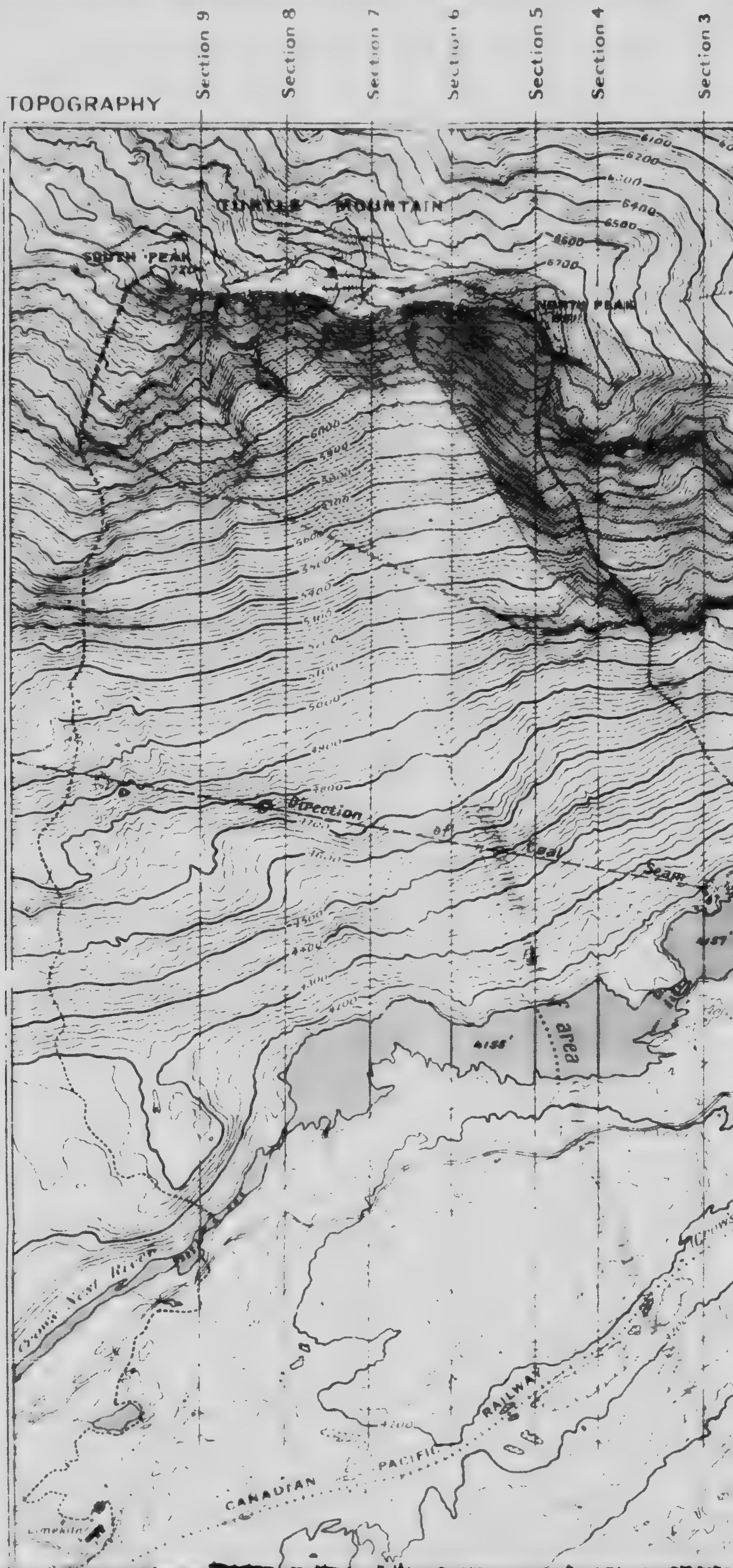
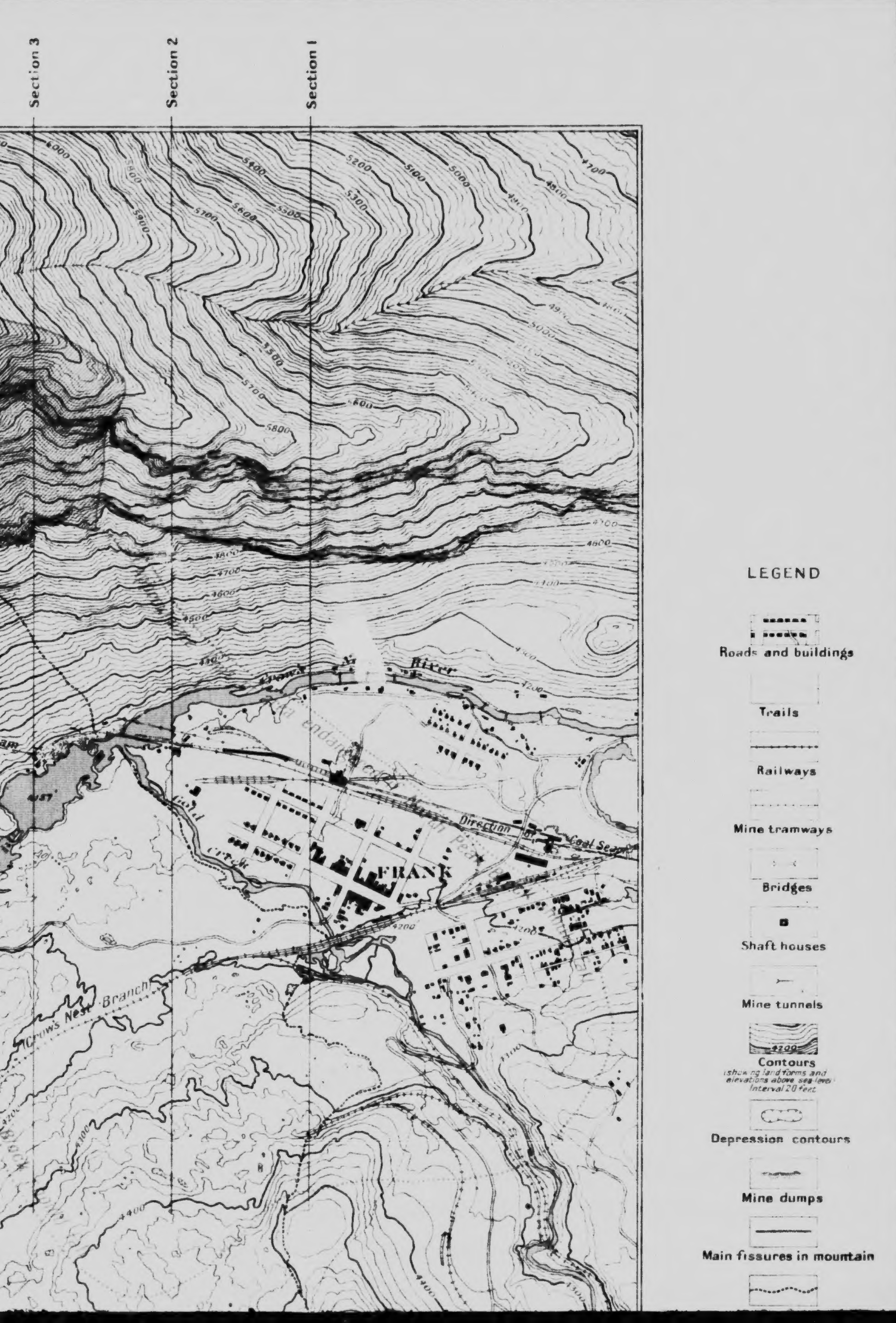
TOPOGRAPHY

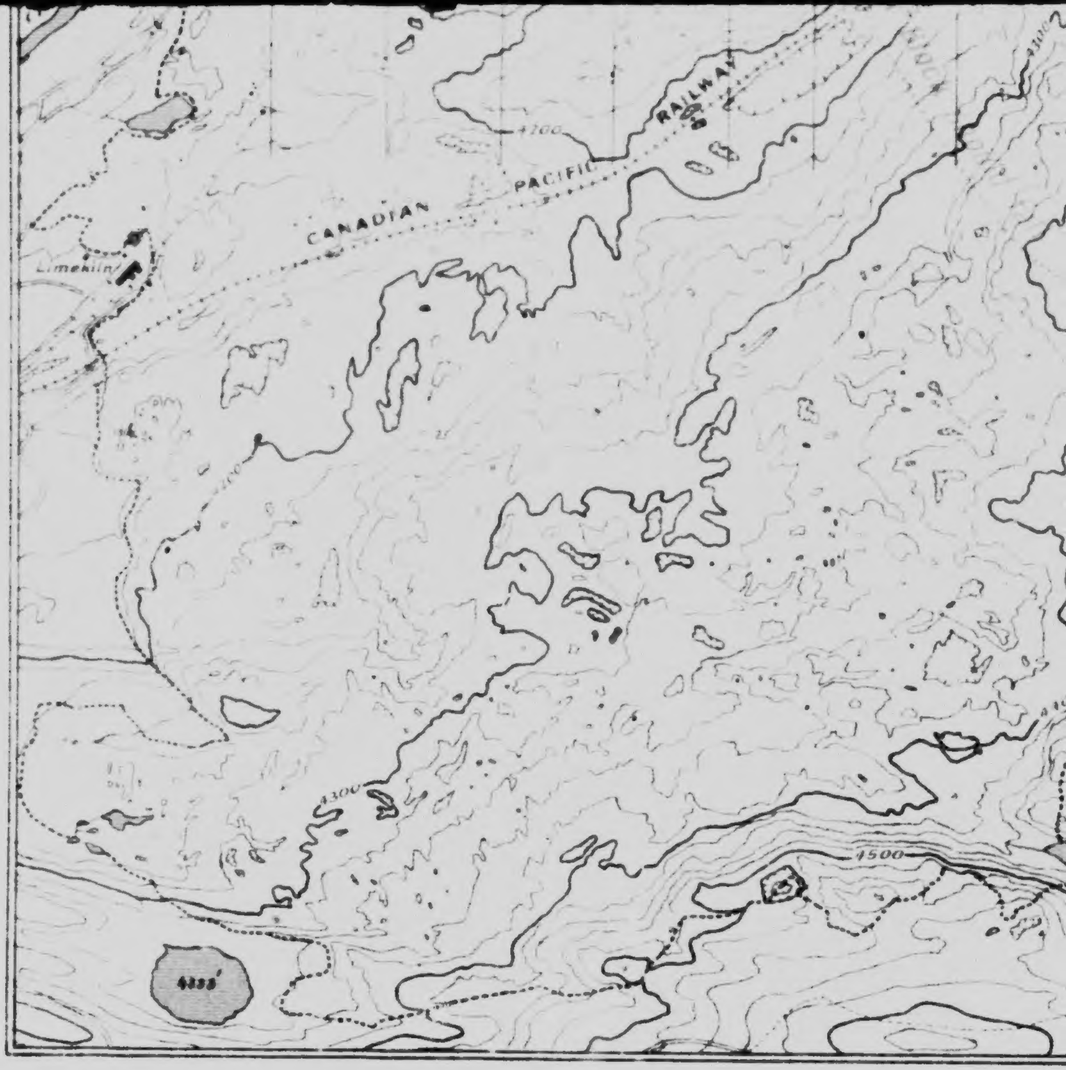


LEGEND

Area of rock now in danger of sliding
(North Peak block)

Area of rock which fell April 29, 1903


Section 3
Section 2
Section I
FRANK
River
Direction
Coal Seam
Creek
Crow's Nest Branch
LEGEND
Roads and buildings
Trails
Railways
Mine tramways
Bridges
Shaft houses
Mine tunnels
Contours
(showing land forms and elevations above sea-level) Interval 20 feet
Depression contours
Mine dumps
Main fissures in mountain



TURTLE MOUNTAIN

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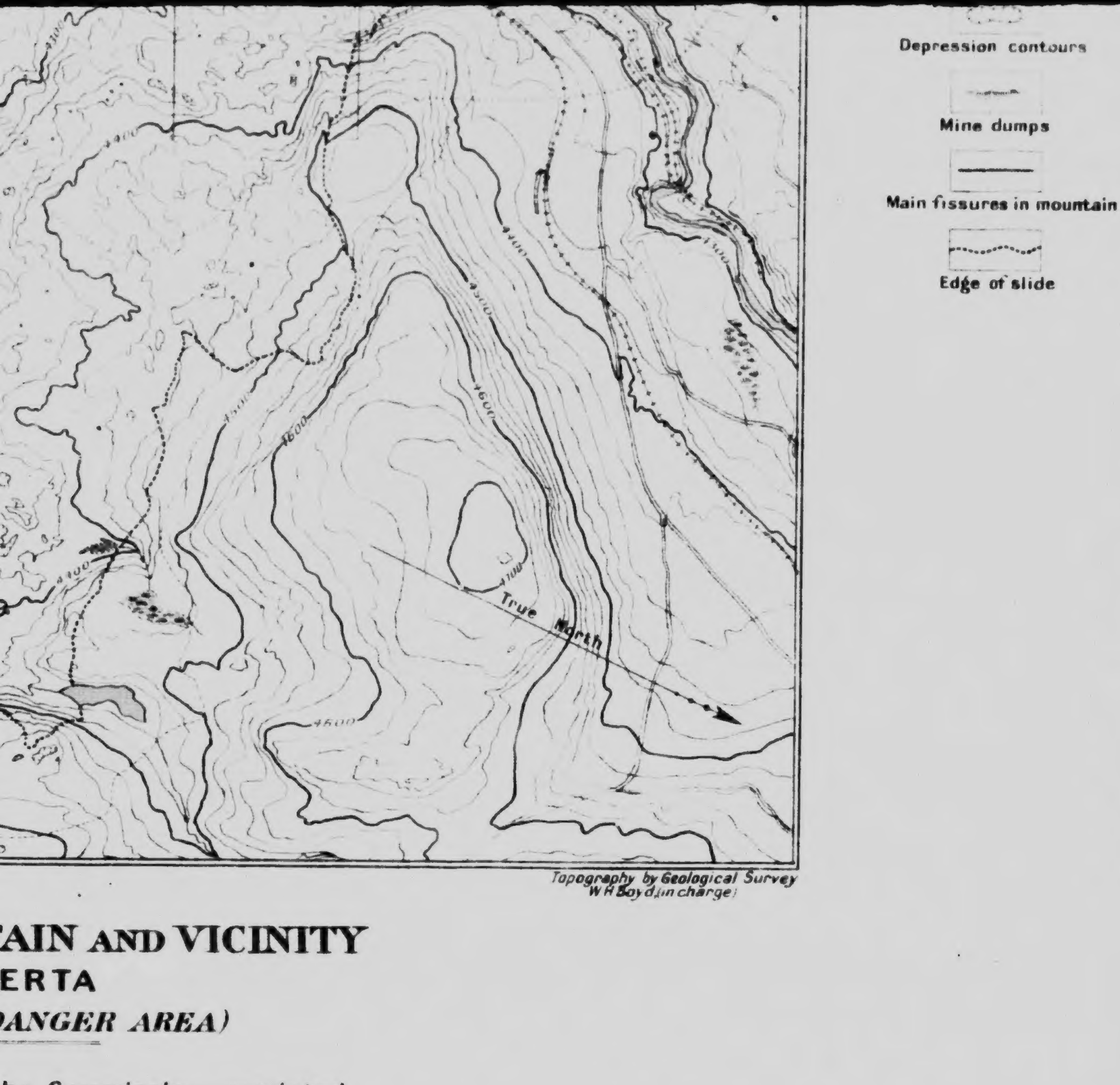

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